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PIAT'S PORTABLE OSCILLATING FURNACES.

It is scarcely more than twenty years ago that ideas of progress began to enter works devoted to casting, and not only have smelting furnaces undergone great improvements since that epoch, but also some important mechanical installations, such as those designed for the manufacture of pipes, have been mounted in foundries, and very ingenious moulding machines have been invented for the production of pieces in duplicate, triplicate, etc. Finally, the art of the founder has been enriched with numerous processes to the great advantage of the mechanician. The smelting of bronze has been still more recalcitrant to progress than the smelting of iron. The ancient smelting furnaces, for example, have been preserved through ages just as the first workmen constructed them. These ancient crucible furnaces present a series of quite grave inconveniences, to remedy which Mr. A. Piat, of Paris, has invented a portable oscillating furnace, which is a great improvement upon the old styles. It greatly reduces the cost of production, it effects the smelting much more rapidly, and, by that very fact, permits copper founders to cast much heavier pieces than they have been able to up to the present without having recourse to reverberatory furnaces. Three or four furnaces permit of casting pieces weighing from 1,500 to 2,000 kilogrammes.

This portable furnace (Fig. 1) consists of a square box of iron plate surrounded at a proper height by a steel belt provided with two trunnions, which permit the furnace to be tilted through the aid of a lever, and, thanks to which, it is likewise possible to lift the furnace by means of a hoisting apparatus and an iron handle mounted upon the collar of the trunnions. The box is lined with a refractory material resting upon an angle iron that forms the base of the furnace. Two strong round bars adjusted in bosses carried by the angle iron receive the part of the steel grate which carries the crucible stand and four or six bars, according to the dimensions of the furnace. These bars are movable and may be made to recede from or approach each other, in order to facilitate cleaning and the removal of the scoria. On the front side of the furnace there is a spout lined with refractory clay, and serving for pouring out the molten metal. The crucible, which rests upon a plumbago stand, is adjusted on one side to the spout of the furnace, and rests on the opposite side against a wedge of refractory clay placed against the furnace wall.

Refractory clay or plumbago crucibles may be used indifferently, but the plumbago ones can be used only for capacities greater than sixty kilogrammes. The furnace rests upon a cast iron plate, which covers an air chamber, into which air is forced by a blower, the supply being regulated by a cast iron register.

It will be remarked that the square form of the furnace permits of effecting a saving in fuel, since the coke lodges in the corners, and the part of the crucible tangential to the sides of the furnace can be very near it.

In order to mount a plumbago crucible, it is placed upon a stand of suitable height, and the junction of it with the spout is effected with a mixture of refractory sand and plumbago. This mixture will melt at the first firing, and will solder the spout and the crucible.

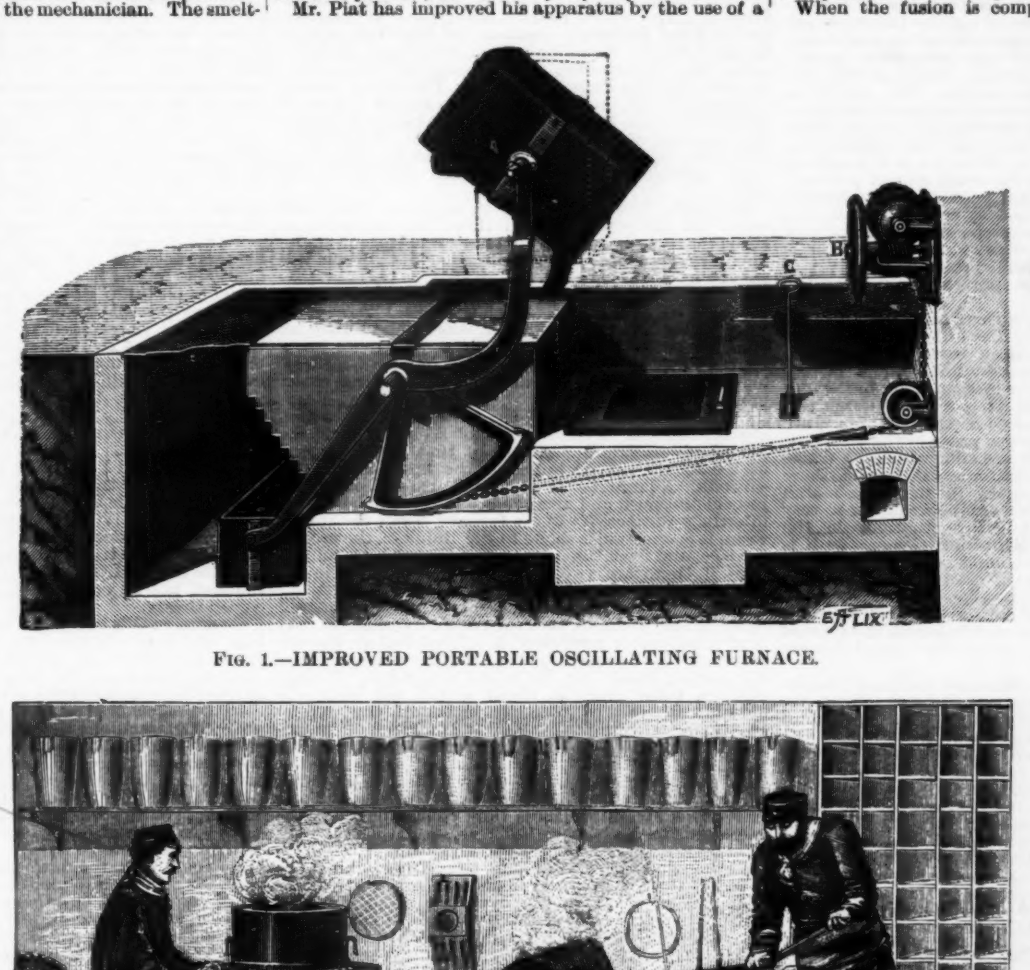


FIG. 1.—IMPROVED PORTABLE OSCILLATING FURNACE.

FIG. 2.—IMPROVED CRUCIBLE CUPOLA.

The crucible having been put in place, a fire of charcoal and a little coke is lighted, without exceeding a cherry red, in order to well dry it, and, when it is absolutely dry, the smelting is begun by progressively opening the vent.

In order to charge the furnace with coke, the crucible is covered with an iron plate hood, and the coke is distributed all around it by means of a basket having, as far as possible, the necessary capacity.

Mr. Piat has improved his apparatus by the use of a *rehausse* and a system of lifting that does away with the use of a crane. The *rehausse* is a sort of crucible containing an aperture in the center of its bottom, and arranged above the true crucible. Openings are arranged upon its circumference at a proper height. At the upper part there are two apertures in the sides, which serve, through the aid of a bar, for removing the *rehausse* or for placing it upon the furnace. The metal to be smelted is no longer introduced directly into the crucible, but into the *rehausse*.

As soon as a draught has been turned on, the flames pass with force through the apertures in the circumference of the *rehausse*, impinge directly upon the metal, heat it, and quickly melt it. The molten metal then flows into the crucible, the function of which is limited to receiving it and keeping it in a state of fusion. When the *rehausse* is employed, the first charge of coke always suffices to fuse the quantity of bronze that the crucible is capable of holding. The air is forced under a pressure of from twelve to eighteen centimeters of water. According to Mr. Piat, 100 kilogrammes of bronze can be smelted with this system in fifteen or sixteen minutes, with a consumption of coke which, in a normal operation, does not exceed fifteen per cent. This is a remarkable result, and one that has not hitherto been obtained. It is possible to run two or three times the capacity of the crucible into a ladle before the metal has cooled. If several 300 kilogramme furnaces are employed, it will be seen, then, that pieces of a relatively large size can be cast.

When the fusion is complete, the *rehausse* is removed, and an examination is made to see whether or not there are any fissures between the crucible and the spout; if there are any, they are luted, the draught is shut off, the spout is cleaned with a bellows, the surface of the metal is skimmed, and the pouring off is begun.

As for the means employed for running off the metal, there is a special apparatus, easily maneuvered by one man, and due to which the oscillation is effected at such a height from the flow that the metal can be readily run into the ladle.

After every smelting, before recharging with coke, care is taken to rake the corners, in order to cause the scoria to fall. After every two or three smeltings the fire is brightened by making the furnace oscillate upon its trunnions, and separating all the bars in succession with a poker in order to remove the scoria.

Crucible Cupola.—The furnace just described is designed for the fusion of copper and its alloys. It may be employed likewise for the fusion of cast iron and malleable cast iron by combining a small cupola with it. The apparatus then takes the name of *crucible cupola*, and is a true laboratory cupola that permits of obtaining smelted iron of an absolutely definite quality, this being something that we are never sure of with large cupolas, and castings of a superior quality, the metal coming into contact with the coke for only a short time.

The furnace, properly so called, remains the same, and the hoisting apparatus also; but it is surmounted, as shown in Fig. 2, with a cupola of small dimensions, provided with a Voisin blower. It is supported by a hollow column, which serves as an air conduit, and around which it is capable of pivoting when the smelting is finished. A screw permits of raising the cupola slightly above the furnace in order to facilitate its rotation. As for the introduction of air, that can be regulated at will by means of a cock.

The draught of air is admitted both into the cupola and under the portable furnace. At the end of about ten minutes, when the bottom of the first is very hot, the iron is put into the cupola alternately with coke, as in the large apparatus of the same type.

In operating upon hot silicious iron, the metal may be run directly into a ladle previously heated, and lined with a thin layer of clay. The cost of heating the crucible and the wear of the latter are thus avoided. The output of coke is then sixteen per cent.—about the normal quantity consumed in large cupolas, firing included.

But if steel pig is operated upon, it is necessary, in

order to have a very hot and very fluid mass, to allow the metal to fall into the crucible, and then the consumption of coke varies from thirty to forty per cent. It is possible to smelt 100 kilogrammes of steel pig in thirty minutes.

Mr. Piat's portable oscillating furnace and crucible cupola are destined to render genuine services in smelting works. More than two hundred of these apparatus have been in operation since the exposition of 1889, in France, Germany, Italy, and England. The use of them has begun to extend in a general manner in the smelting industry, and it is probable that it will greatly increase when smelters have found out the serious advantages that these apparatus present, from all points of view.—*Le Genie Civil.*

PROGRESS OF THE STARCH INDUSTRY.

ACCORDING to the last statement from the Bureau of Statistics, about 14,000,000 pounds of starch were exported during eleven months of last year, against half of that quantity for the year previous. We are informed by good authority that the export movement was somewhat larger, and that most of the starch sent abroad is disguised as flour to prevent competitors from tracing the shipments, hence the Bureau of Statistics is not to blame for inaccurate figures. The movement of corn and potato starch to the four ports of the United Kingdom has been unusually large for the past few months on account of the short crops of corn and potatoes on the other side. It is very unusual to send potato starch out of the country, and previously the article was imported to the extent of 509 tons per year, but during the past eight months no foreign starch has arrived. This product of the potato is yet of comparatively small importance, as its use is confined to the mill trade. The total production is estimated at 11,000 tons per annum, which is 500 tons more than the consumptive outlet. The article is made by various small concerns throughout the country. Indications point to a scarcity and higher prices on account of the large quantity used for making dextrine since last autumn. The latter is a new American product, made necessary by the small crop of potatoes in Europe, and the consequent light supply of foreign dextrine, which formerly had no competition in this market. In case of better crops next summer and thereafter, the importation of dextrine will no doubt be resumed as usual, as it is claimed that the new duty of 1½ cents per pound will not prevent its sale on the American market.

Corn starch is the leader, with an annual production of about 350,000,000 pounds. The number of factories in operation has been reduced from twenty-five to thirteen because of over-production. Some of the larger mills are working from 1,000 to 8,500 bushels of corn per day, as only twenty five pounds of starch can be obtained from a bushel of corn. Manufacturers are complaining of the very narrow profit in the business, and were it not for the odds and ends which are transformed into gums for special uses, it is said there would be absolutely no money in the corn starch trade, except for those firms manufacturing on a very economical basis. The violent fluctuations in the corn market are always a disturbing element, as it is not an easy matter to determine when to lay in supplies. A favorable purchase of raw material leaves the manufacturer of starch in a position to meet competition, but a high market for corn may rob him of his profit for a while at least, as an advance in the price of raw material must be permanent to have any influence on starch.

The rivalry between the combined forces and the independent faction continues, but the competition for trade is devoid of the unpleasant friction experienced when the combination was formed.

Wheat starch is another article that is over-produced, although there are only seven mills devoted to its manufacture. The consumption does not exceed 10,000,000 pounds per annum, but efforts are being made to push its sale as a substitute for corn starch in the laundry and among industrial establishments of the East.—*New York Price Current.*

THE USES AND APPLICATIONS OF ALUMINUM.*

By G. L. ADDENBROOKE.

THE utility of a metal in the arts is governed by its physical properties and the price at which it can be produced in an available form. I propose, therefore, as a commencement, to deal with both of these aspects of the question this evening, in order that a fairly correct basis may be arrived at on which to estimate the uses to which aluminum is applicable; and, in what I say, it must be understood that I refer generally to aluminum itself, or to aluminum alloyed with a few per cent. of other metals, unless it is mentioned to the contrary, and not to aluminum bronzes, or bronzes consisting chiefly of copper alloyed with a few per cent. of aluminum.

Let us commence with the cost of the metal, as that so largely determines its sphere of usefulness. Just three years ago, in this room, Mr. William Anderson described the Deville-Castner process, which had then just been put in operation by the Aluminum Company of Oldbury, near Birmingham. It was then stated that it was proposed to manufacture aluminum at 20s. per lb., or at about one-third of what its price had been previously, and still leave a satisfactory commercial profit. These anticipations would have been duly realized but for the contemporaneous perfection of the electrolytic methods of reducing aluminum, which being brought into use on a large scale, have resulted in an enormous reduction in the cost of production, and this has constantly reduced the market price of aluminum in a manner which is probably without parallel in the industrial history of metals. Starting three years ago, as has been mentioned, at 20s. per lb., the price of aluminum quickly fell to 15s., then to 13s., next to 8s. and even 6s. It was thought about a year ago that the climax, for the time being at any rate, had been reached when the Pittsburg Reduction Company, of Pittsburg, Pa., announced that they were prepared to supply aluminum at a dollar, or 4s. 2d. per lb. But the competition chiefly of the Aluminum Industry Company of Neuhausen, Switzerland, whose works are operated by water power and are on a large scale, has led to still further reductions, and at present, in considerable quantities, aluminum of 99 per cent. guaranteed purity is obtainable at 2s. or even less per lb.

On anything like the present output this price is hardly a remunerative one for the companies engaged in production; and it seems to me that it is improbable that there will be much greater reduction at present. On the other hand, I do not think the price is likely to rise very much again, because a larger consumption of the metal would make this rate a paying one, which would lead to increased output. This, then, is the cost basis on which we have to estimate the openings for aluminum during the next year or two, a cost, bulk for bulk, not greatly exceeding that of copper, for at present the cost of copper is about 5d. per lb., and, since it is 3½ times as heavy as aluminum, the latter, at 2s. per lb., would equal copper at

$$\frac{24 \times 2}{7} = \text{say 7d. per lb., or a relative cost for equal quantities of 5 for copper to 7 for aluminum.}$$

It may be interesting to outline briefly the processes by which these astonishing results have been obtained, particularly as finality has by no means yet been reached; and should the uses of aluminum warrant a largely increased output in the future, considerably better economical results could be attained.

As usual, success has been achieved by the labors of many minds, but there are two patented processes under which most of the aluminum at present made is being manufactured. The first is that of Mr. Hall, of Pittsburg, Pa., whose patents are owned in America by the Metal Reduction Company, of Pittsburg, and in England by the Metal Reduction Syndicate, of Patricroft, near Manchester. The second is that of M. Heroult, a young French engineer. This latter process is controlled by the Societe Electro-Metallurgique, of Troyes (Isère), in France, and by the Aluminum Industry Company, of Neuhausen, Switzerland, at which latter works the largest plant in the world for the reduction of aluminum and its subsequent working is situated.

Although, however, two in name, there is, in fact, very little difference between these two processes, so far as the details have been made known, and therefore, for my purpose this evening, one description will answer for both.

In both cases the oxide of aluminum, or alumina, Al_2O_3, is the material from which the metal is reduced. This is dissolved in a fused flux, consisting of fluorides of aluminum and sodium, which simply serves as a vehicle to carry the alumina. The furnace for effecting the operation is made in the form of an iron-cased box, which is thickly lined with carbon, having a cavity in the center into which the materials for reduction are introduced. Two or more of these furnaces are placed in series, and one pole of the dynamo is connected to the carbon lining of the first, forming the cathode. A large block of carbon carried on an adjustable support, and arranged so that it can be dipped into the central cavity of the furnace, forms the anode. From it connection is made to the lining of the second furnace, and from the carbon anode of the second furnace, if there are two, the main passes back to the other terminal of the dynamo.

In starting the plant, the carbons are brought well down in the furnaces, and the current turned on. At first considerable resistance is offered, but as the materials in the furnaces get warm this decreases, and the carbon anode can be raised somewhat. Decomposition takes place at about a full red heat, the alumina is resolved into its elements, the oxygen partly unites with the carbon, and is given off as carbonic oxide, and partly escapes free, while the aluminum sinks to the bottom, and gradually accumulates. When a sufficient quantity has collected, it is tapped off and run into moulds without interrupting the process of reduction, which is thus continuous. As the aluminum in the furnace is decomposed, the resistance rises, as the workman can see by watching the ammeter, and this is an indication to him to add more alumina.

It will thus be seen that the process is a pretty simple one. First, we have the dynamos, which must be driven by steam or water power, and which, as they are operated continuously, can be worked to the best advantage. The load is fairly even, and therefore the wear and tear on this part of the plant should be small.

Then we have the furnaces, which are not expensive, and will only require the carbon lining and anodes renewed occasionally.

Lastly, the flux, acting simply as a carrying vehicle, needs only small additions from time to time. The four great items in the cost of production of aluminum are, therefore, the cost of the electric energy, of the alumina required, wages and superintendence, and depreciation and interest on capital employed.

Now, in the Hall process, it is found that 22 electric horse power flowing through the bath, at a potential of 8 to 10 volts, for one hour, is what is required to reduce 1 lb. of aluminum, and this can easily be produced by the combustion of half a hundredweight of coal, which at 10s. per ton means a cost of 3d.

As to the alumina, I am informed by the Metal Reduction Syndicate that the anhydrous alumina which they use, and find most suitable, on account of its freedom from impurities, costs £30 per ton, and yields about 50 per cent. of its weight in aluminum. The cost, therefore, of the raw material is at present about 6d. per lb. for the aluminum contained.

The cost of the pound of aluminum then totals up to 2s. 9d. per lb. for the aluminum extracted, unless indeed water power is employed, as at Neuhausen, where the first item is of course considerably reduced.

Coming now to the capital required, a horse power of plant, working for 24 hours, produces in practice about 1 lb. of aluminum. Supposing the plant works 300 days a year, we have 300 lb. of aluminum as the product of an indicated horse power of plant working for a year. Now, such a plant as this could easily be erected complete, including buildings and all accessories, for £30 per indicated horse power available; and supposing we take upkeep at 10 per cent., and interest and profit at 10 per cent., this represents £6 per annum to be spread over 300 lb. of aluminum, or 5d. per lb., which is a very liberal estimate, and may well include the cost of carbons and fluxes. For these three items then we have a total of 1s. 2d. per lb. Finally come labor, superintendence, and administration expenses. These so much depend on the output, which at present is small, that I shall not attempt to estimate them. It will be sufficient for my purpose if I have shown that the present price of aluminum ingots, say 2s. per lb., cannot leave much margin of profit on the present rates of output, which are about as follows: The Aluminum Industry Company, 1,000 lb. per diem; the Pittsburg Reduction Company, 600 lb. per diem; the Metal Reduction Syndicate, of Manchester, 300 lb. per diem; Cowles Company, 600 to 750 lb. in alloys. At the same time it is sufficiently near the remunerative level to prevent any great advance, except by a reduction of output, or some agreement among manufacturers.

To get further cheapness, a larger demand and production are needed, which must come within a moderate time, when we may safely calculate on aluminum comparing at any rate on equal terms with copper as to price for equal bulks; but from what I have shown I think it is pretty clear that we cannot look for much reduction on the price I have named in the immediate future. Improvements will certainly take place in the processes of manufacture, and I feel very hopeful of them, but they will probably be in details rather than in any fundamental alteration of the present electrolytic process of reduction, and will chiefly take the form of improvements in the methods of obtaining pure alumina or some other salt of aluminum, and in the method of operating the furnaces, in which at present only about 25 per cent. of the energy is utilized for reduction directly, the rest being absorbed in heating the materials. Electric heating has so far been, I believe, found preferable to direct heating, but I cannot help thinking that, at any rate where steam engines are employed, further experience will lead to improved forms of apparatus being devised, which will admit of the heat required being applied directly and more economically than through the intermediation of a steam engine, which, as a heat producer, is so very inefficient.

To pursue these lines of thought further would be speculative, whereas my object this evening is of a more practical nature; therefore, having settled on an approximate price at which aluminum will be obtainable for present use, it remains to be seen what field this price, coupled with this peculiar physical and mechanical properties, will enable it to occupy.

Within the last ten years the quality of metal manufactured has been very much improved, and the larger quantities in which it has been dealt with have given better opportunities of estimating accurately its nature than was possible before. Most of the metal made is now of over 99 per cent. purity, and the reduction in the amounts of iron and silicon contained in it, which are the chief impurities, has altered and improved its working qualities considerably, when it has to be rolled, spun, and drawn.

To show exactly what its properties are, I have here a cast bar of pure metal, about ½ in. wide, ⅜ in. thick and 1 ft. long. Taking the ends of that in my hands, you will see that I can bend it double, bringing it into the form of a rather elongated O, without breaking; that is about the limit of what it will stand. As regards hardness it is rather softer than copper, and in the lathe, or under the file, behaves in much the same way, having a strong tendency to pull, and tear, and clog the tools. Like copper, too, it is softened by being plunged hot in cold water, and hardened by being cooled slowly.

Clearly, in this state, it is not very suitable for castings, and, just as zinc and tin are added to copper to improve its qualities, so some similar additions must be made to aluminum, if it is to be as useful in this form as its other qualities lead us to anticipate.

In the endeavor to improve the qualities of aluminum, without detracting appreciably from its characteristic properties of lightness and incorrodibility, I have gone over some old ground, and perhaps entered a little new, and a few notes on the results of additions of other metals to aluminum may be interesting, as the literature on this subject is rather fragmentary and incomplete, and early experiments were mostly performed with impure metal.

To begin with, the pure metal does not cast quite so well, nor is it as hard or strong as when it contains 2 to 3 per cent. of silicon, though its malleability is decreased, and it has a scratchy, sandy feel.

The addition of iron appears to be simply detrimental, leading to porous castings, while the metal is of a rotten nature.

Copper gives much better results; it hardens the metal considerably, when added up to 5 or 6 per cent. After this brittleness is produced.

My experience with copper, however, is that the alloy does not stand remelting well, but soon becomes porous; on the other hand, until it has been several times melted, and allowed to stand, scum is apt to form, and mingle with the metal, producing bad marks in the casting. The metal also still pulls in the lathe. Silver alloys with aluminum very well, but its cost puts it out of court for most purposes.

Zinc hardens aluminum, and also toughens it when added to the extent of 3 or 4 per cent., but the resulting metal is difficult to turn, and the alloy is not a very clean one; it does not stand remelting well.

The addition of tin appears primarily to have two actions—up to three or four per cent. it makes the aluminum short, but improves its turning qualities; if 10 per cent. is added, the bar is at first as pliable as the pure metal, and of about the same strength, but if this metal is once or twice remelted it soon becomes crystalline.

Nickel has much the same effect; when added to copper, it however produces a closer grain, though still leaving a bad surface under the tool.

Though the qualities of aluminum therefore are improved in some respects by the addition of alloys, none of them seems to produce alone quite what is wanted. In combination, however, better results are obtainable, and I have here some specimens made by the Phœnix Engineering Company. The exact composition of these I am not at liberty to disclose at present, but it will be seen that the metal is both whiter and much harder than aluminum, while it can be turned with practically the same facility as brass, leaving as good a surface. A good example of the alloy will have a rigidity slightly superior to ordinary cast brass, though it cannot be bent to the same extent; however, it is still fairly malleable, and bears considerable extension under the

* Read recently before the Society of Arts, London. From the *Journal*.

hammer. As with so many other alloys, the best results are obtained after the metal has gone through a certain amount of mixing and remelting; afterward frequent remelting renders it more brittle, and is apt to produce porosity. This, in fact, constitutes the chief difficulty in casting aluminum and it is aggravated by the fact that most of the objects hitherto made in aluminum are small, while, owing to the lightness of the metal, higher heads are needed than for brass or iron; there is therefore necessarily a good deal of remelting if metal is not to be put aside. This difficulty is, however, one which practice and the use of aluminum for an increasing number of objects will diminish.

To illustrate what can be done with this alloy, I have here a dumpy level made from it, including all the screws and working parts. Further, I have camera screws and nuts, tripod heads, and a portable galvanometer, while Mr. Dallmeyer has been kind enough to send down examples of his lenses, particularly his new ones, all the parts of which, except the tubes, have been made of this alloy. It will be noticed that satisfactory screws can be cut in the metal. I have here also a specimen of a small resistance box, of which the top is made of it, and which appears to answer very well.

The alloy will also be useful, I think, for the frames of light motors, and for some of the working parts, for parts of portable microscopes and telescopes, range finders, heliographs, projectors, arc lamps, field telegraph apparatus, stands for portable lamps, and for a considerable number of other purposes where a fair degree of strength and rigidity is needed, combined with lightness and incorrodibility.

Before passing on from the consideration of alloys, I must mention the beautiful one of aluminum and gold, containing, I believe, about 23 per cent. of the former metal, which has been discovered by Professor Roberts-Austen, and which he has been kind enough to bring to-night. In structure it is crystalline, but the interesting point about it is its beautiful rose pink color, which is quite different from anything that has been observed in metal before.

Of alloys with aluminum in general, it may be said that they decrease its malleability, and that, for metal which has to be rolled or drawn, it is usually expedient to employ the pure metal, in fact the purer the better. I think, however, that as the handling of the metal is better known, some of these alloys may prove useful, and provide us with harder sheets and wires of higher breaking strain than can be obtained from aluminum itself.

Passing now from cast aluminum to rolled and drawn. There are on the table some 5 lb. ingots cast in iron moulds, such as are used for rolling from. These can be rolled right down into sheets of any thickness cold and without annealing, of which there are several specimens before you, ranging from the ordinary grades down to one which I have, and which is only $\frac{1}{1000}$ of an inch thick; while, to proceed further, foil can be beaten out into leaves, the thickness of which is about $\frac{1}{40000}$ of an inch. This leaf has almost entirely superseded silver for gilding on account of its permanences, as a good instance of which I can show you a book of leaf which was made in 1868, and has been in London since. You will perceive that it is as bright as the day it was made.

Sheets of aluminum cold rolled become very hard and quite springy; in fact, their rigidity is greater than that of ordinary brass sheets. They will stand a fair amount of bending, and can quickly be made quite soft by annealing at a temperature of about 400°. It is evident that such sheets are applicable to a number of purposes in the flat. For instance, they have been used for making canoes and the hulls of steam launches, or for parts of photographic cameras. Sheaths for holding photograph films and a number of the parts of portable instruments are also readily made from aluminum sheet, and it will also, I think, have a future for ornamental work for electroliers and gas brackets, especially in conjunction with iron work, with which it forms an excellent contrast; but its greatest value lies in forming the substratum, so to speak, for stamping and spinning.

Of the various useful articles which will be made of aluminum in the immediate future, it is safe to say that a large proportion will be stamped or spun, for aluminum lends itself particularly well to this work, and anything that can be so made in other metals can be carried out in aluminum. It has, like other metals, a few peculiarities of its own which require to be mastered, but when this is done, we have a metal which is as tractable in the hands of the workman as silver. As instances, there are on the table some fine stampings of a couchant lion and examples of buttons, also forks, the backs of brushes, etc., which show how much can be accomplished, and what a nice effect the work has.

Of spinnings, Messrs. Still & Co. have been kind enough to send some fine examples: there is, for instance, a stethoscope entirely spun up, including the tube and both ends, from a circular plate, such as I have here; a more perfect specimen of what can be done with a metal, and what it will stand, it would, I think, be difficult to conceive—though so light, it is yet very rigid. There are also examples of surgical specula; an ewer and basin; and, lastly, some helmets for firemen or military purposes; these, Messrs. Still & Co. assure me, they consider as strong and stiff as ordinary brass, of which there is also an example, that its weight may be compared with those of aluminum.

Then I have here an example of the aluminum flask, of which so much has been said lately in connection with the German army; it will be observed how light and strong it is. For comparison there is another somewhat similar one of English manufacture. The uses of aluminum for cooking utensils, probably for cartridge cases, should also be noted here.

Lastly, there are some very interesting plaques and picture frames, the work of the Scovil Company, of New York, which are an interesting example of scratch brush work.

Turning now to a slightly different field, here are examples of tubes. Some provided by the Mannesmann Company, as examples of their power, are 12 or 14 ft. long, and of excellent quality. For the remainder I am indebted to the Phœnix Engineering Company. All these tubes, I need hardly say, are solid drawn; and it will be noted what excellent examples of workmanship they are. For telescopes, and wherever lightness is essential, they must supersede brass or German silver. Whether they will answer for bicycles still remains a moot point. I have tested two sets of tubes of the same dimensions—one of steel and the other of aluminum—in the following way. The tubes were supported in V grooves a foot apart, and a lever was brought down on the center of the tubes between the supports, a pad and narrow ring being used to secure a fairly even pressure. The lever was then adjusted, and it was found that the aluminum tubes stood about half the strain of the steel tubes, though their collapse was a little more complete on passing the critical point. As an instance, an aluminum tube one inch in diameter and 40 mills thick stood a strain of 200 lb. applied in this way. This, I think, must be considered very satisfactory.

Of the applicability of aluminum to opera and field glasses it is needless to speak, but there is an example on the table of a glass made in 1864, which has been in constant use since. In 1870 the wheel of a carriage passed over it, but it was afterward straightened out and made usable. It has made two voyages across the Atlantic, two across the Pacific, and has had other shorter experiences of the sea air, besides lying on one occasion for some time in salt water. This disposes of the idea that aluminum is readily spoiled by contact with sea air. For my part, I have kept strips of aluminum for two or three weeks in salt water, and have noted very little effect.

I might continue this somewhat discursive paper further, and it is obvious that I have only enumerated a few of the uses to which aluminum can be put, but I have rather relied on showing from the examples before you that aluminum is an easily workable metal, and can be worked into almost any form which metals, such as copper, brass, and silver, are capable of assuming, having once grasped which, each in his own sphere can find uses to which it adapts itself. At its present price, it can be classed as eminently a useful metal, and the lower the price becomes, the wider will be its sphere of utility.

There is, further, one goal toward which aluminum workers will look forward, and the attainment of which it is not unreasonable to expect in the future. At present the price of aluminum is about four times that of pure copper for equal weights, and its output is little more than a ton a day for the whole world. In the improvements in the process of reduction, and an output of some thousands of tons per annum, is it looking too far ahead to anticipate that the price will be reduced to that of copper, when aluminum, with its conductivity of 200 per cent. that of copper—weight for weight—would, in a large measure, replace the latter metal for mains for electric lighting?

In what I have said nothing has been mentioned about solder. I have here an example of some joints I have had made, which are fairly satisfactory. Strength of joint is secured, but the process of making it requires a good deal of care, on account of the high melting point of the solder and the difficulty of getting it to flow readily. Still, it can be done. Messrs. Balfour & Co. have, however, informed me that they have a solder which they propose to bring out shortly which is a great improvement on previous ones. They have brought some examples of work done with it tonight, from which it will be seen that the joints are quite invisible. I have not yet seen any actual joints in the process of being made, but aluminum workers will await further results with interest.

DISCUSSION.

The chairman said Mr. Addenbrooke had referred to the probability that where steam engines were employed further experience would lead to improved forms of apparatus, which would admit of heat being applied directly; but it seemed to him that that was very doubtful if the heat were applied to the carbon, which was the reducing agent, because it required more heat to dissociate aluminum than it did to dissociate the products of the reduction, which he held in this case was carbon anhydride. He held the effect was due to the combined effect of heat and the dissociating influence of the tearing electric current. But of course this was a matter for discussion. Mr. Addenbrooke had referred to the interesting alloys of aluminum with other metals, and mentioned some facts which were perfectly new to him, especially that nickel and aluminum appeared to disintegrate spontaneously. There were other cases in which alloys behaved in that peculiar way, but they were very rare. He also referred to the alloys of aluminum with the precious metals, and on one of the series he had carefully worked recently, and found that alloys of aluminum and gold possessed certain peculiarities which deserved very careful attention. The melting point of gold was 1045° C.; when alloyed with 10 per cent. of aluminum, the melting point fell about 400°, and the alloy was as white as silver; but on adding another 10 per cent., the melting point rose to 20° above that of gold itself and the alloy was a brilliant purple. By adding further quantities of aluminum, the melting point was again reduced until it came to that of aluminum itself, about 650° C. He believed that was the only case known, free from mercury, in which the melting point was higher than that of the least fusible of the constituents, and pointed to the fact that the union of the two metals must be very peculiar indeed.

Mr. S. G. Gordon said the paper was very interesting, and he regretted that he could not add any information, as he had very little opportunity of doing anything with aluminum except seeing the working of it by the Mannesmann process. In that way pure aluminum worked very satisfactorily, as was proved by the spinning, and in other ways. The Mannesmann Company had made large quantities of aluminum tubes, and found that as long as the metal was pure there was no difficulty in working it, and it would stand repeated rolling, cold, without injury. It had been mentioned that a small quantity of silicon had a great influence on the casting properties of the metal, and that was a line of research which should be followed up, the alloys which had hitherto been made having usually consisted of a fairly large proportion of other metals.

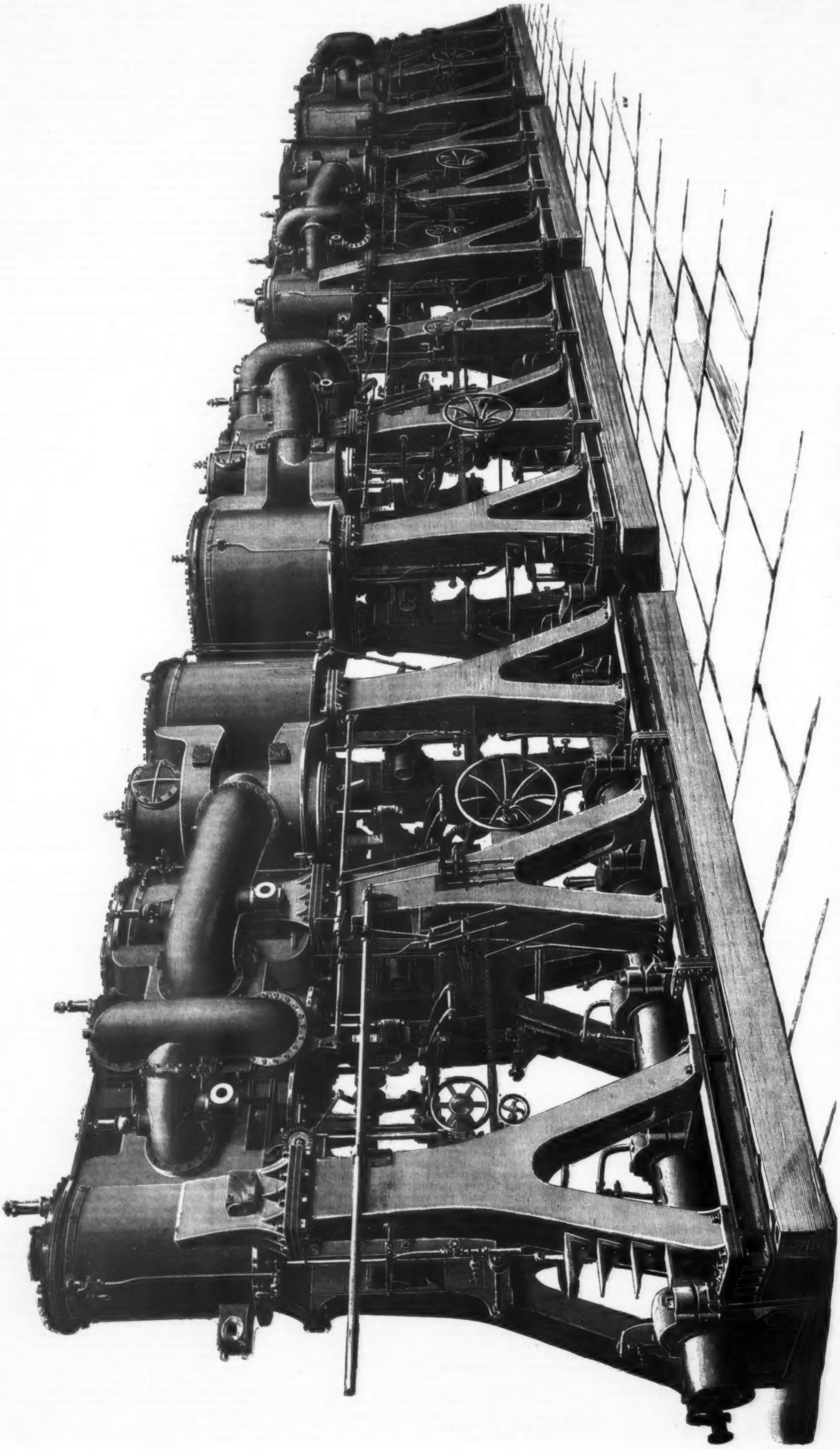
Mr. B. H. Brough said he exhibited, at one of his late Cantor lectures, a series of mine-surveying instruments, made of aluminum, to show its applicability to such purposes. Of course, lightness in this case was of the utmost importance; and any one who had to carry surveying instruments through the tortuous passages of a mine, or up the steep sides of a mountain, where every additional ounce became a grievous burden, would appreciate that; but, since then, he had had an opportunity of testing the wearing capacity of these instruments, and did not find them altogether satisfactory. He had used a theodolite as an educational instrument, with a class of about thirty students from the school of mines, and it did not stand the hard usage it was thus exposed to. The screws stripped, and the wear had been very bad, so that it might be safely asserted that aluminum was unsuited for such instruments where an occasional stress had to be borne; for whenever the metal was bent out of shape it seemed almost impossible to restore its original adjustment. He noticed in that week's number of the German mining journal a note about the Neuhausen Aluminum Works, stating that about 54 per cent. of the daily output was consumed by German steel makers, as an addition to molten steel, with a view to obviating the formation of blowholes. If that were so, it seemed a very important use, and worth mention in the paper. When the members of the Iron and Steel Institute visited the aluminum works at Pittsburg, they had presented to them, as a souvenir, a little aluminum box, which was one of the prettiest objects he had ever seen. It consisted of a very tasteful design, and showed very clearly how ornamental workmanship in this metal could be made.

Mr. C. W. Parker (Messrs. Balfour & Co.) said he was not at liberty to go into much detail on this matter, but there was no doubt that this metal was very useful and his firm had just produced a very reliable solder, the best yet tried, which would be a great service in many ways. One great point about it was that it did not oxidize, and, further, it amalgamated with the metal in the soldering. On one of the pieces he had sent, it had been hammered, and though the metal had bent, the joint had not given way. The solder was composed of aluminum and tin; was patented, and instructions for using it would be given to licensees.

Mr. Walter T. Reid said the question of soldering seemed to be of great importance. The composition of one had just been published in *Dingler's Journal*, consisting of 50 cadmium, 20 zinc, and 30 tin. Like other aluminum solders, it was said to be better than the metal itself, and to do everything required of it. He had made some experiments in soldering aluminum, and found that one of the chief points was a flux to cover the joint, as you then had a much better chance of getting a sound joint. Probably the surface of the metal became covered with a thin film of alumina, which prevented the solder flowing. He had also made a few experiments with aluminum as pure as it could be obtained, and had one or two failures to record. It did not answer his expectations, perhaps because they were too high. He found it would not stand sea water, nor even a solution of pure chloride of sodium: the metal was corroded in a very peculiar way, almost as if there were impurities in it, but on cutting out the corroded portions, and testing them, he found they were as pure as the bulk of the metal. Another thing he tried it for was cartridge cases, but, he found, when subjected to atmospheric influences, either with black powder, or with some of the niter compounds which formed the basis of smokeless powders, it was corroded, not perhaps more than brass, but quite enough to interfere with the strength of the metal. It was well known that the pressure of a very small quantity of sodium had a very deleterious effect on this metal. He should like to ask Mr. Addenbrooke if he had any information as to the action of ordinary liquids used for beverages on aluminum. Some time ago, in the German papers, there was some allusion to an alleged case of poisoning through the action of brandy on the metal of one of these flasks, and although not proved, the statement was sufficient to discourage their use.

Mr. Parker said the solder he referred to required no flux. There was a specimen on the table which had been in a salt bath for some time, and it was not at all oxidized.

Mr. Addenbrooke said he thought the chairman hardly understood his reference to the use of heat: he did not mean to reduce the metal, but simply to bring the bath to a red heat, which was now done by the current itself. In electric heating you had to put coal under the boiler, turn the water into steam, pass it through the engine, and then operate the dynamo, which was an uneconomical mode of producing heat, though of course you had the heat inside the furnace instead of outside, which might help to balance it. With regard to alloys of aluminum with small quantities of other metals, the work he had done had been with aluminum of over 99 per cent. purity, and in ordinary work he had noticed that the addition of ½ per cent. of other metals did not make much difference; you required 1 or 2 per cent. before perceiving any effect, but no doubt by testing the breaking strain accurately, you might find there was a difference. It must be remembered that you had, say, ¾ per cent. of impurity to start with, so that it was impossible to say what was due to the added metal, and what to the impurity. Perfectly pure aluminum had not been furnished, and he did not think its electrical resistance had yet been accurately determined. It was tested some time ago, when the metal might have had from 2 to 3 per cent. of impurities, and they knew what a great difference a slight impurity made in the resistance of copper. The figure usually given was about 56 per cent., but in some samples he had measured he had found 58 per cent. of copper. The mention of the survey instrument introduced a point on which some stress ought to be laid. People talked about aluminum as if it were something quite definite, whereas, for all these instruments, an alloy of some kind ought to be used. If they were made of a suitable alloy, he would not say they would have lasted as well as brass, but they would certainly wear better than ordinary aluminum even with a little silicon in it. With regard to the addition of aluminum to steel and bronze, he did intend to refer to it, as it was exceedingly interesting, but he thought the scope of the paper was large enough without going into it. One gentleman said he found he could solder aluminum better with the use of a flux, but the usual methods were without any flux, which was generally found to be a nuisance. He had noticed some discrepancies, with regard to the action of salt, but fancied they might be traced to the fact of a rather impure



THREE-STAGE COMPOUND ENGINES OF THE NEW CRUISER NEW YORK.

sheet being rolled cold. It that were the case, it disintegrated in laminæ, and the salt got underneath and forced out the metal, forming a sort of exfoliated surface. With a really pure metal, well rolled, there was very little action indeed. He had put some in salt water with various organic matters and left it for weeks, and it was very little acted on. He also put some in a bottle of cider and left it uncorked for many weeks, and there was very little action. Most of the soldering must be done with a blowpipe, but an aluminum bit to work over the surface was a useful addition. The difficulty was that the solder did not flow well. You had to heat the metal up to a certain point, when it was just beginning to disintegrate, apparently before the solder began to take, first it went to a pasty state, and then, on a rise in temperature, it began to flow. He hoped the new solder spoken of would be more successful. The melting point of the solders he had used was nearly that of aluminum, and it was almost impossible to do fine work with it without many failures; you were so apt to melt the sheets. There was a method of autogenous soldering by bringing the two surfaces together, and pouring metal on to them until the edges melted and united together, and then cleaning the metal off; it could also be done by means of electricity, but he had not had much experience of these.

ENGINES OF THE UNITED STATES CRUISER NEW YORK.

WE give illustrations of the engines of the United States armored cruiser New York, one of the vessels built under the 1889 programme, which included seven cruisers and seven armored ships. The design of the New York has been described as between the British ships Edgar and Blake, which latter was recently illustrated in SUPPLEMENT 857. The New York is 380 ft. 6 in. in length on water line, 64 ft. 10 in. wide, and her designed mean draught was 23 ft. 3½ in., the displacement at that draught being 8,150 tons.

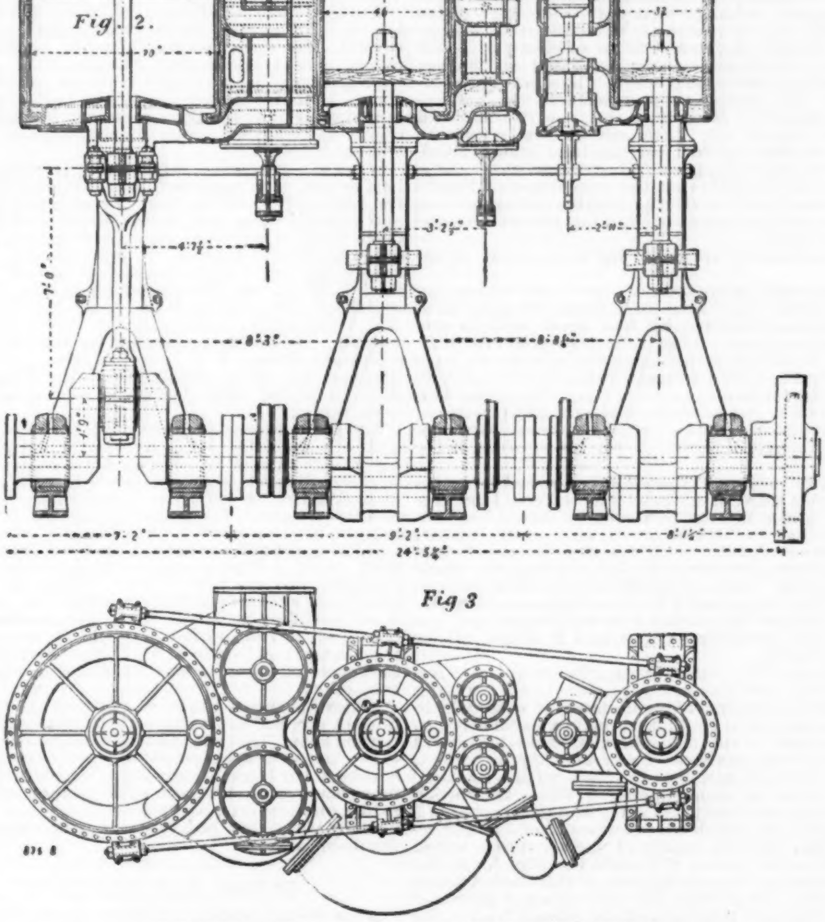
One of our illustrations shows the whole of the propelling engines in perspective, and a very long perspective they make. The ship is propelled by twin screws. As will be gathered, there are two sets of three-stage compound engines to drive each propeller. In this feature the New York resembles the Blake and Blenheim and the big Italian vessel the Sardegna. The cylinders are 32 in., 46 in., and 70 in. in diameter, and the stroke is 42 in. Piston valves are used exclusively, the high pressure cylinders having one valve each, while the intermediate and low pressure cylinders have each two valves. The high and intermediate valves are 16 in. each in diameter, but, for the purpose of balancing, the low pressure valves are made of different diameters, the mean being 29¼ in. The links are of the Stephenson type, with double bars as shown. The frames which support the cylinders are of cast iron, and the crossheads run on cast iron guides bolted to the frames. The bed plates are of cast steel of I section, and are bolted to the engine keelsons, built into the ship. The piston rods, connecting rods, and other working rods are of mild forged steel. The crankshafts are also of mild forged steel, each one being built in three sections. The forward shafts are 13¼ in. in diameter, with a 6 in. axial hole; the after shafts are 17 in. in diameter, with axial holes 7½ in. in diameter. There is a cast steel coupling between each after and each forward engine crankshaft, so that the engines may be quickly coupled or uncoupled. It is the intention to use the after engines only for moderate steaming. Each engine with its auxiliaries is located in a separate water tight compartment and will be entirely independent of the others. The main condensers are of composition. They are composed of three sections, which are bolted and riveted together. The sections are 5 ft. 9 in. in diameter and have a total length of 9 ft. between tube sheets. Each condenser contains 3,776 tubes of No. 20 B. W. G. thickness of metal. The outside diameter is ⅝ in. and the cooling surface 5,560 square feet. Each tube is packed separately, so as to allow them to expand and contract independently. The total cooling surface is 22,240 square feet. Refrigerating water is supplied by separate centrifugal circulating pumping engines, there being one to each set of main engines, having a capacity of 8,000 gallons per minute. The air pumps are single acting, each with two pistons 25 in. in diameter, and 18 in. stroke. They are driven by vertical engines with cylinders 12 in. in diameter and of the same stroke as the pumps. The steam cylinders are placed directly over the pumps.

Steam is supplied by six double-ended steel boilers arranged in three groups of two abreast below the protective deck. There will be two auxiliary boilers above the protective deck. There are three chimneys. The following are the particulars of the boilers: 15 ft. 9 in. diameter and 18 ft. long. Eight furnaces of 3 ft. 3 in. in diameter to each boiler. The grate bars are 6 ft. 4 in. long. The tubes for main boilers are of steel 2¼ in. outside diameter. The tubes for the auxiliary boilers are 2¼ in. in diameter. The main boiler shells are 1⅛ in. thick. The total main boiler grate surface is 988 square feet, and the total main boiler heating surface is 31,005 square feet. The working pressure is 160 lb. The collective horse power (including auxiliaries) is estimated at about 16,000 indicated, when the main engines are running at a piston speed of about 903 ft. per minute or 129 revolutions. Mild forced draught will be used on the closed stokehold system. The propellers are three bladed, twin screws, made of manganese bronze, and are 16 ft. in diameter with 20 ft. pitch. The two auxiliary boilers are each 10 ft. in diameter and 8 ft. 6 in. long. The grate surface for both will be 64 square feet and the combined heating surface for the two 1,952 square feet. We are indebted to *Engineering* for illustrations and the above particulars.

The contract for the New York complete was awarded by the United States Navy Department to the Wm. Cramp & Sons Ship and Engine Building Company, of Philadelphia.

Fig. 2.

Fig 3



ENGINES OF THE U. S. CRUISER NEW YORK.

ON THE UTILIZATION OF THE WASTE FORCES OF NATURE.*

By W. H. PREECE, F.R.S.

THE sun is the *fons et origo* of all the available energy upon the surface of our earth. Countless ages ago its warm and vivifying rays promoted the growth of plants and ferns and trees, which, falling where they grew, formed those great beds of coal now being brought to the surface, and which, combining with the oxygen of the air, provide us with heat and power to supply our wants, to maintain our manufactures, and to expedite our locomotion. These same rays are now in a similar way hastening the growth of trees and making wood, the difference between wood and coal as fuel being only age. They are now also furthering the annual growth of grasses, corn, fruits and vegetables to become food for beast and for man, and to supply them with fuel to maintain their life, their strength, and their capacity for work. The same rays playing on the surface of the waters promote the evaporation of the liquid into gas, which, mixing invisibly with the air, gives evidence of its presence when the lowering of temperature causes its condensation into the floating clouds and its ultimate return into the waters in the form of the gentle rain, the rippling brook, the roaring torrent, or the flowing river. The sun's rays, again, produce that variation of temperature in our atmosphere leading to currents of air which sometimes fan our faces with cool and refreshing breezes and at other times rage and roar with the relentless fury of a tornado. The sun, together with the moon, so attracts the mobile waters of the ocean that it produces great periodic waves and currents known as the tide, which ebbs and flows with such uniformity and regularity that we can calculate the rise and fall of the water at any particular spot, and its rate of flow, not only at the present day, but for any future time, provided the geographical conformation of the land and the bottom of the sea remain unaltered.

Coal and oil pent up in the bowels of the earth and water accumulated in the higher levels of the land are our great stores of energy, available for the wants and purposes of man. The wind, the running streams, and the flowing tide are the passing forms of energy which are available for our present use, while food is the particular form of fuel which maintains life and provides the means of doing work. These are all natural sources of energy; while gunpowder, gas, compressed air, steam, chemical affinity, etc., are artificial sources which the ingenuity of man has fashioned for his use.

In that interesting work of Smiles, "The Story of the Life of George Stephenson," we read: "One Sunday, when the party had just returned from church, they were standing together on the terrace near the hall, and observed in the distance a railway train flashing along, throwing behind it a long line of white steam. 'Now, Buckland,' said Mr. Stephenson, 'I have a poser for you; can you tell me what is the power that is driving that train?' 'Well,' said the other, 'I suppose it is one of your big engines.' 'But what drives the engine?' 'Oh, very likely a canny Newcastle driver.' 'What do you say to the light of the sun?' 'How can that be?' asked the doctor. 'It is nothing else,' said the engineer; 'it is light bottled up in the earth for tens of thousands of years—light, absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth, if it be not carbon in another form; and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought forth and liberated, made to work, as in that locomotive, for great human purposes.' The idea was certainly a most striking and original one; like a flash of light it illuminated, in an instant, an entire field of science."

I have used the words, *work*, *energy* and *power*. *Work* is the effort exerted when we overcome resistance. When we walk upstairs we overcome the resistance due to the attraction of the earth, and we raise our bodies to a higher level. Work is thus done by ourselves on ourselves. When a train is moved from Liverpool to Warrington, the friction or resistance of the rails is overcome as well as that due to gravity (for we go up hill). Work is thus done by the locomotive on the train of carriages. Force has been applied, resistance has been overcome through a certain distance, and this is the measure of work expended. But this capacity for doing work must exist in a dormant state both in our bodies and in the locomotive, and this is called *energy*, which is stored up in food and in fuel, energy being simply the capacity for doing work. While the work done or energy expended is measured by the distance through which resistance has been overcome and by the weight of the object moved, the *rate* at which the *energy* is expended or the amount of work done per minute or per second is the *power*. Power is, therefore, the rate of doing work. Watt called the work expended in one minute in raising 33,000 lb. (14¾ tons) one foot high a *horse power*, and this is the same as raising 550 lb. per second. A man can raise ⅛ cwt. per foot per second for a short time. A horse dragging a cart of materials weighing one ton over a level road at a speed of four miles an hour exerts this power; and one of Mr. Webb's locomotives driving an express train over the London and North-Western Railway at sixty miles an hour may expend about 750 horse power. Fourteen gallons of water falling four feet per second could perform about the same work as this typical horse, and thus a horse power becomes a very convenient though rough and unscientific measure of the rate of expending energy.

Energy is expended when coal or wood is burnt, when water falls, when tides flow, when the winds blow, when food is digested; and the function of steam and gas engines, of water wheels and turbines, of windmills and of beasts of burden, is to transmit this energy to some spot where it can be utilized for the wants and purposes of man. But water is ever falling in the mountains of Wales, shining rivers flow on forever and forever, the tides ebb and flow daily in our straits and estuaries, the wanton winds expend their energies always over the surface of the land; and man neglects these stores of energy that Nature gives him at his very door.

Let us assume that we have at our command, at one spot, some source of energy, such as a steam engine or a water turbine, how can we transmit the power exerted to some other spot where it can be better utilized? Belts and shafts and ropes are at our command. A 4 in. rope, moving at a speed of 2,000 ft. per minute, transmits 8 H.P. The valleys of Switzerland abound with such conveniences. We may even lead the water itself in pipes and channels, and in America they even distribute the live steam over considerable areas. Gas is a very convenient medium for the distribution of actual energy, and since the advent of the electric light its use for this purpose has been very

* Read before the Liverpool Welsh National Society and the Liverpool Engineering Society, April 6, 1892.

largely encouraged. In the United States it is found in a natural state underground, and it is being conveyed to distances of even 100 miles.

Compressed air is a very convenient medium for the transmission of energy. It is largely used in mines. In London it is employed for the transmission of telegrams, and in Paris it is in successful work for postal work and for a large number of industrial pursuits. 10,000 H. P. can be transmitted 20 miles in a 30 in. pipe by air at 132·3 lb. pressure, with an efficiency of about 40 per cent., that is, about 60 per cent. of the original energy is wasted or lost in transit. The efficiency of a system is the ratio of the energy utilized to the energy expended. Thus to get 1,000 H. P. at the end of pipe 20 miles long, we must expend 2,400 H. P. at the beginning.

The common way of transporting energy is by cart, or by train or by ship. Thus coal and wood are carried anywhere, but at a price. This also means an efficiency, for the cost to the consumer is much enhanced by the carriage of the material. Coal at the pit's mouth costs 6s., in Liverpool it may cost 18s. per ton; its efficiency is thus 33 per cent. In London we have been paying 30s. per ton; the efficiency is, therefore, only 20 per cent. There is another mode of transmitting energy, and that is by the electric current. It is not my intention to occupy your time with a description of a dynamo. It must be known to most of you; electric exhibitions have made us familiar with the principal industrial electrical apparatus. The dynamo is an instrument designed to convert the mechanical energy of motion into the form of energy called electrical. The answer to the question, "What is electricity?" is now, "Principally coal and sometimes water." Five pounds of coal consumed per hour in a furnace flashes 50 lb. of water into steam. The steam in its reconversion to water transfers its energy to a moving mass of machinery, a part of which consists of copper rods forming a portion of an electric circuit. These rods rotate in a magnetic field where work is done on them, and where, in consequence, the mechanical energy of motion is converted into the molecular energy of electricity. The 5 lb. of coal have produced $1\frac{1}{3}$ H.P., or 1,000 watts in the circuit; in fact, a kilowatt is the scientific unit of power, and a kilowatt-hour is the Board of Trade unit of energy for the use of which the Electric Lighting Company of Liverpool is allowed to charge 8d. A watt is the energy expended by an ampere when driven by a volt. It is equivalent to nearly $\frac{3}{4}$ (actually 0·737) of a foot pound. The ampere is the unit current, and the volt the unit electrical pressure. A 16 candle glow lamp requires 100 volts and 0·48 ampere to incandesce it into brilliance. It therefore absorbs 48 watts and consequently 1 c. p. is produced by 3 watts. Hence, a kilowatt-hour uniformly expended will give us 333 candles continuously, or it will maintain 21 such lamps alight. But this kilowatt of energy need not have given us light; it could have been converted into other forms of energy; it could be used for electro-metallurgical purposes; it could deposit copper; it could produce aluminum; it could break up salt solution into chlorine and caustic soda; it could silver our plate and gild our cups; it could be reconverted into mechanical energy by electric motors; and could again drive machinery, turning mangles, knife-cleaning machines and ventilators in our dwellings, sewing machines in our shops, blowing organs in our churches, driving tramcars on our streets and trains on our railways. Again, it could give us heat, warming our rooms, heating our irons, and, as we see every day in the Crystal Palace, boiling our water and cooking our food.

I am anxious to attract your attention especially to the facility which the electric current gives us to bring power to our doors and to enable us to facilitate home industries. The congregation of large bodies of males and females in magnificent buildings is a modern consequence of great industries dependent on the presence of great power and great steam engines. A system of centralization has followed, which is not always beneficial to healthy mental and corporeal growth. The electric current steps in to check this system. It enables us to apply in our own dwellings power from the smallest fraction of a horse power to many hundred horse powers.

Moving water as a source of power is already utilized to a very large extent. At Bushmills, near the Giant's Causeway, in Ireland, there is a fall of 26 ft., which, actuating turbines, produces currents of electricity that drive a railway from Portrush, a length of six miles. This line has been at work since 1883. Between Newry and Bessbrook, also in Ireland, there is another railway worked electrically, in the same way and of the same length. At Lynton, in Devonshire, and at Keswick, in Westmoreland, the fall of water is used for electrically lighting the two places; while at Tivoli, near Rome, 2,000 H. P. is going to be converted into electrical energy which will be transported 18 miles to Rome to light up 40,000 lamps. At Geneva the lake which merges there into the river Rhone flows through the town with considerable velocity, and more than 3,000 H. P. is there obtained, not only for electric lighting purposes, but to raise water to a height of over 400 feet, so as to distribute its energy over the whole town for the innumerable watch, musical box and other industrial purposes for which that town is so famous. At Schaffhausen (the famous falls of the Rhine) about 600 H.P. is converted into electrical energy, and is applied to the production of aluminum, and 700 H.P. for the transmission of power to a woolen spinning mill about half a mile away, the wires crossing the river. At the Skippers Creek Mountains, near Otago, in New Zealand, two 50 H. P. turbines generate electrical energy, which is transmitted three miles to work quartz stampers. At the Virginius mines in Colorado some unprofitable mines at a height of 12,700 feet have been made profitable by the utilization of water at the foot of the mountain. Labor has also been reduced. Two pumps, a hoist, a blower, and two mills are worked by electric motors, 1,200 H. P. being available for transmission four miles up the mountain by current.

The economy of the transmission of energy by electricity is a question of pressure. The higher the voltage (pressure) the smaller the conductor needed and the greater the distance to which it is possible to transmit the energy. It is difficult to obtain high voltages except through the aid of alternate currents and by means of induction apparatus which transform low to higher pressure. The apparatus for doing so is extremely simple and effective. The Ferranti apparatus in Deptford generates 10,000 volts directly by a dynamo which drives currents eight miles to London, and is there retransformed down first to 2,400 and then to 100 volts for electric lighting purposes. At Lauffen, on the Neckar, a turbine worked by the falls there absorbing 300 horse power with a head of 10 ft. excited a dynamo to 50 volts and 4,000 amperes. These low-pressure currents passed through a transformer which raised the voltage to 16,000 volts. Three small bare overhead copper wires (No. 8 gauge), insulated on oil insulators, conveyed this energy to Frankfort, 108 miles away, where it was transformed down to 75 volts, and there used both for motor and for lighting purposes. The apparatus worked during the existence of the Frankfort exhibition last year, and it is now employed in lighting electrically the town of Heilbronn, nine miles distant from the falls, but at a pressure of 5,000 volts. The peculiar feature of this Lauffen system is the use of three wires and three alternating currents, one in each wire, flowing at different phases, following each other like the relative motions of the three cranks of a three-cylinder steam engine or of a three-throw pump. This "Drehstrom" cures all the defects of alternating motors; it causes no disturbance to contiguous telephones and telegraphs; it is sparkless and safe, and the apparatus is remarkable for its simplicity.

The system has been practically worked out by Tesla in the United States of America, and by Dobrovolski in Berlin. It solves the question of economically transmitting energy to great distances. Coal may be burnt at the pit's mouth, and 75 per cent. of its useful electrical energy delivered in London. The energy of the Swallow waterfall at Bettws-y-Coed may light up the streets of Liverpool. The foaming torrents of the Highlands can be made to drive the tramcars of Glasgow. It is proposed to transmit energy by this method from Niagara to Chicago next year—a distance of 500 miles—and this can certainly be done with a voltage of about 40,000 volts, and with an efficiency of about 60 per cent.; 5,000 horse power generated at Niagara would deliver 3,000 horse power at Chicago. The principal cost of the system lies in the construction and upkeep of the wires; the cost of the plant is small and the labor insignificant. It remains to be seen how the relative economy of coal carriage and energy transmission will affect this great industrial question. Anyway, we may conclude that the experiment at Frankfort has practically solved the question of transmitting energy to a distance and of working motors by alternating currents.

How then are we to utilize the waste forces of nature?

The sun's rays pouring on the desert of Sahara are generating the equivalent of millions of horse power in the heat absorbed by that great sandy waste. Sunshine is power. Coal is merely preserved sunbeams. The solar heat acting on one acre in the tropics would, if it were possible to utilize it, produce 4,000 horse power for nine hours every day. To utilize this heat is not a mere dream; it is certainly possible to convert it into electrical energy by thermo-electric apparatus, though I have not yet heard of its being done.

The earth itself in its daily rotation round its axis is an immense store of energy. If we could by any means reduce a little of this spin we should lengthen the day, but we should obtain energy. Mr. Gisbert Kapp has calculated that if the day increased only one second 100 years hence we should during the whole of this century obtain 10,000,000 horse power continuously. There is no doubt that the tidal wave is gradually acting upon the earth's spin in this way, but the energy is not available for man, and it is one of our wasted energies.

The tides of the ocean, surging backward and forward with unerring accuracy, produce in our estuaries and straits movements of great masses of water which, if utilized as power, could be turned to useful account. Take the case of the Menai Straits, whose breadth at Belan, the entrance from Carnarvon Bay, is 1,188 ft., and mean depth about 50 ft. This gives a sectional area of water of approximately 60,000 sq. ft., flowing either in or out four times a day at a mean speed of 3 knots per hour, which gives a velocity of 5 ft. per second. The effective energy of such a stream would give 6,000 horse power if it could be utilized. At the present moment not one fraction of this wasted power is employed other than for the motion of ships and boats. The total tidal area of the estuary within the mouth of the River Mersey at New Brighton is 22,500 acres. The mean total volume of tidal water passing in or out of the estuary four times a day is 4,455 million cubic feet. The mean rise or fall of the water above tide level is $10\frac{1}{2}$ ft.; that is, the mean vertical range of the tide at Liverpool is 21 ft., reaching 31 ft. on equinoctial springs and 10 ft. on lowest neaps. This would give an available power of about 100,000 horses, if it could be utilized; but this is, of course, an impossibility.

In some estuaries the flood tide is caught by dams in a kind of dock and made to work mills in its ebb, but with a rise and fall of 6 ft. it requires a dock area of 10 acres to give 20 horse power. But tide mills are very expensive in their prime cost, and they are rarely resorted to unless nature has favored their use by unusually high tides or by convenient geographical configuration. The power executed by tidal rivers is much less than is usually considered. The total tidal energy of the Thames at London Bridge is 320 horse power, from which we could not extract usefully more than 100 horse power, and that only by stopping the whole navigation of the river. The available energy passing through one archway is only 20 horse power. The total available energy of a slow shallow tidal river like the Thames is therefore comparatively small, and its inconvenience would be so great that it is not worth consideration.

It is different with a constant flowing river. In a constant moving mass of water the work done per second by the stream depends on the pressure exerted by the water on the effective float area exposed to the stream and on the rate at which the water flows. The whole energy of a stream running at 5 ft. per second (3·4 miles per hour) against a resisting float surface of 5 sq. ft. would exert approximately one horse power, and if the efficiency of our machinery be 50 per cent., 10 sq. ft. will give us about one effective horse power. Hence it is not a difficult problem to utilize the energy of a current of water on a small scale, especially as the energy increases as the cube of the velocity.

An extremely ingenious hydraulic motor has been devised by two young engineers, Messrs. Purdon and Walters, of Great George Street, which, moored in a stream, absorbs the energy of the moving water in a novel and effective way, and converts it directly into electrical energy. One is going to be fixed in the upper reaches of the Thames to form a charging station for electric launches. The energy of the falling river will thus be utilized to drive boats up the stream against its own resistance. The quantity of water going down the Seiont from the beautiful lake of Llanberis is approximately five million gallons per day, and it falls about 300 ft. Hence the whole energy of the river, if it could be utilized, would supply a constant power of 320 horses. There are already several mills on the stream utilizing some of this power; but enough remains, at any rate, to illuminate the streets of Carnarvon with the electric light. Forty million gallons of water will be daily brought to Liverpool from Lake Vyrnwy when the system is complete. The top water level of the lake is 820 ft. above the level of the sea. The total energy continuously expended by the fall will therefore be about 7,000 horse power.

Of course, much of this energy is expended in overcoming the friction against the sides of the aqueduct, in delivering the water into the houses of the consumers in Liverpool, and in maintaining the service, but there must be a good deal of energy wasted; and it is well worth the consideration of our water authorities whether some utilization of this wasted energy in water works generally cannot be effected so as to deliver it in the form of electrical energy in our streets and buildings. The whole of the streets of Liverpool could be brilliantly lighted by the energy wasted in the Vyrnwy aqueduct.

Water as a source of energy is found where nature has placed it, and not where it can be most conveniently used. The electrician has, however, interfered with nature, and has enabled man to extract the otherwise wasted energy, and to lead it where he wills. The energy of moving water has not hitherto been much sought after in the United Kingdom, because coal is cheap, but now that strikes are rampant, the wise seek wind and water.

Wind is a somewhat fitful source of energy, but it has served its purpose and has done good service in the past. It is still in great request upon the ocean and in lands where coal is dear and air is cheap. It is much used for irrigation, and its energy can be stored either by raising water or by accumulating chemical energy in secondary batteries. Mr. Brush, in Cleveland, U. S. A., has used a windmill to light his house, and Messrs. Carwardine & Co., in the City Road, London, utilize about 3 horse power in this way every evening. An ordinary windmill, having four sails, in a pleasant breeze of 10 miles an hour, gives about 2 horse power; and the small American circular mill, so much in request now, gives on an average about one horse power.

The power exerted increases with the area exposed, and with the cube of the air velocity. A wind blowing at the rate of 10 miles an hour, or say 15 ft. per second, will exert such direct pressure on a sail 130 sq. ft. in area that it will drive a boat before it with the power of a horse. The largest sailing ship in the world has just been launched at Port Glasgow, which carries a sail area of 57,000 sq. ft., and has a tonnage of nearly 4,000. Such a wind would exert upon her a power equivalent to 440 horse power. Wind is, however, practically available only for small powers, and in exposed positions on land. There are, however, many places where country houses could be supplied with the comfort and luxury of the electric light if this errant force of nature were curbed and brought under subjection.

While our wants are so readily and so cheaply supplied by our coal fields there is little chance of much attention being directed at present to other sources of energy; but with the diminution of our output, and the cranks of our labor communities, the attention of our manufacturers and of the custodians of our health, safety, and comfort must be directed to those neglected energies which are now "wasting their sweetness on the desert air."

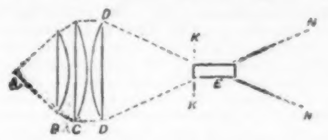
LENSES FOR LANTERNS.

AT a recent meeting of the Camera Club, London, with Captain W. de W. Abney, R.E., C.B., President, in the chair, Mr. W. H. Harrison read a paper, in the course of which, after speaking of the educational uses of instruments for optical projection, he said that he wished to raise the question whether in those cases in which a lime light is not employed the illumination of the screen given by oil and other ordinary flames, used in the present average lanterns, cannot be more than doubled. If so, an obstacle to the use of the lantern in private houses and in small halls can be removed; for large displays, of course, the lime light will hold its own. Private individuals who may desire to have a lantern in the house, to be used occasionally by all sorts and conditions of operators, may not like, and in some localities may not find it convenient, to use compressed gases. Although we are occasionally informed that the gas bottles are absolutely safe, we with equal regularity read that some lantern user has been killed by an explosion, and when it is urged that it was not the bottle which exploded, but the regulator or some other adjunct, the reply may be given that whichever did it is but a matter of petty detail, of no interest to the corpse.

The leading points which he urged were, that with the present oil lantern the illumination of the screen can be vastly increased: (1) By the use of a better optical system; (2) by the employment of improved burners; (3) by the burning of better oils or gases. There is evidently considerable advantage in the use of properly made triple condensers for the lantern, in place of the double condensers at present in use, despite the assertions of some high authorities to the contrary. The double condensers in the market take in angles of light varying from about 40° to nearly 60°; good triple condensers have been made to take in angles of 90° to 95°; so it stands to reason that if that light be not lost after collection, but all be thrown upon the screen, the screen must be vastly better illuminated by the

triple condenser. We have, therefore, now to notice where light may be lost by the faulty construction of such a condenser.

Let A be a radiant source throwing light at an angle of say 90° upon the lens B—the first element in the triple condenser B C D. The lens B will not render the rays parallel; consequently, that none may be lost, the next lens C must be of larger diameter than B to pick them up. If it be argued that the diameter of B may be increased for convenience in mounting, all other conditions remaining the same, the answer is that some loss of light will result because of the extra thickness of the glass of that part of B then utilized,



and the lens will be more liable to be cracked by the heat. Hence, should any triple condensers come into the market with all three lenses of the same diameter, they should be rejected.

A part of the diagram shows how much light is sometimes lost in the present oil lanterns by the projection lenses being too small in diameter. Much of the light coming from the condenser then cannot enter the tube, E, carrying the projection lenses. By holding a sheet of white paper at K K, the size of the luminous area at that plane can be seen, and whether the projection lenses are sufficiently large in diameter can be ascertained. Unfortunately a fixed tin cone attached to the lantern sometimes prevents a sheet of paper being placed at K K for the purpose, and it is then not so easy to ascertain how much of the light which should pass through the projection combination falls upon the sides of that tin cone; he had known much light to be lost in an oil lantern, otherwise a good one, from the cause just described. Large projection lenses are more necessary with a large flame than with a small luminous source.

With a large flame the definition does not equal that with the lime light; but the pictures are viewed from a distance, and the public are not particularly critical on this point. The chief point to be achieved is to throw plenty of light upon the screen, so far as pleasing a general auditory is concerned. It were better that a meniscus lens should be used at B, instead of a plano-convex lens. The only objection is that the former is more expensive. The glass of the lenses should be colorless, and each lens in the condenser should have a sharp edge. "Good "optical" glass is not necessary; colorless, ordinary good glass will do. As regards burners, the speaker recommended the abolition of the present three-wick paraffin lamps, and the uneven illumination which they give upon the screen, and the substitution of three-ring concentric Argand burners, whether for gas or oil, and fitted with the Douglass cones, as used by Trinity House. He also spoke in favor of the use of oil gas on Pintsch's system, but as this is not readily obtainable in private homes, he also recommended common gas passed through a proper vessel in which it should be saturated with crude cheap benzole.

THE COMPASS: HISTORICAL, THEORETICAL, PRACTICAL.*

By Capt. D. WILSON-BARKER, Lieut. R.N.R. (of the Silvertown Telegraph Company's staff).

HISTORICAL.

THE earliest mention of the loadstone having the property of communicating its mysterious nature to iron is in a Chinese dictionary in the year 121 A. D. We find the earliest reference to the compass in the 64th year of the reign of Ho-ang-ti (2634 B.C.) The Emperor Ho-ang-ti attacked one Tchi-yeou, in the plains of Tchou-lou, and, finding his army embarrassed by a thick fog raised by the enemy, constructed a chariot for indicating the south, so as to distinguish the four cardinal points, and was thus enabled to pursue and capture Tchi-yeou. The name of this chariot or compass carrier was Tchi-nan (chariot of the south), and it is remarkable as illustrating the conservatism of this extraordinary people that it is little different from their name for it in present use. We also see from this that the four cardinal points were thoroughly recognized.

The first authentic mention of the use of the compass at sea is in the great Chinese Encyclopedia Poi-weu-yun-fou between the years 265-419 A.D.

The earliest European mention of the cardinal points is in Homer's Odyssey, Book V., where describing the situation of the wrecked Ulysses, the poet says:

"The rolling flood,
Now here, now there, impell'd the floating wood
As when a heap of gather'd thorns is cast,
Now to, now fro, before the autumnal blast;
Together clung, it rolls around the field;
So roll'd the float, and so its texture held;
And now the south, and now the north, bear sway,
And now the east the foamy floods obey,
And now the west wind whirls it o'er the sea."

They used E. and W. as we use N. and S; thus they spoke of an E.N. wind instead of a N.E. wind, and so on. But though the Greeks and Romans were aware of the magnetic properties of certain substances, no mention is made of the compass until the end of the 11th century, when from the remarks made by Ara Frode, a Norwegian historian, there is strong evidence that the compass needle was known; and within the next hundred years its use had spread all over Europe.

Various assertions have been made that it was invented in Europe, Flavio of Amalfi generally receiving the credit—indeed, the compass appears on the arms of the province in which he was born; but it seems that this idea probably sprung from his being the first to attach the card to the needle, an invention in itself quite sufficient to make his name famous. It was, however, some time before this improvement came into general use.

We have the following interesting account of the compass, as used on board ship, from a MS. by Bailak in 1242: "We have to notice among the properties of the magnet, that the captains who navigate the Syrian seas when the night is so dark as to conceal from view the stars which might direct their course according to the position of the four cardinal points, take a basin full of water, which they shelter from wind by placing it in the interior of the vessel; they then drive a needle into a wooden peg or cornstalk, so as to form the shape of a cross, and throw it into the basin of water prepared for the purpose, on the surface of which it floats. They afterward take a loadstone of sufficient size to fill the palm of the hand, or even smaller, bring it to the surface of the water, give to their hands a rotatory motion toward the right, so that the needle turns on the water's surface; they then suddenly and quickly withdraw their hands, when the two points of the needle face N. and S."

The early compass bowls were made of wood or china, and were marked with lines at right angles inside for the four cardinal points; the magnetized needle was then floated in water in the bowl, either by being supported by a piece of wood or cornstalk, as before described, or else placed on a pivot which was surrounded by water; or the needle was sometimes made in the shape of a fish which floated loosely in the bowl. The first needles made were very small and short, those suspended by the Chinese being particularly sensitive, but they were (in Europe) gradually made longer, so that they might be more easily seen, until in the 16th and 17th centuries we find them 6 in. to 9 in. long. It is curious to note in connection with this the recent return to short needles.

We have no mention of the deflection of the compass needle from the N. and S. direction commonly called the variation, until the middle of the 13th century; and its true meaning was not understood until Columbus took his celebrated voyage across the Atlantic in 1492, but in the 17th century we find the azimuth compass in regular use. At what time the word "compass" was first employed, is unknown, but we find that in the 14th century the compass was known as an "adamant" or "sail stone."

In 1544, Hartmann discovered the inclination or dip of the needle; but to Robert Norman, "a skilled sailor and ingenious artificer," belongs the credit of, in 1576, establishing it as a fact. In Dr. Gilbert's book "De Magnete," published in 1600, we find a very full account of magnetism, as it was known at that time, and this treatise is really the foundation of the modern science of terrestrial magnetism.

Barlow, writing in 1616, describes "the compasse needle being the most admirable and useful instrument of the whole world, is both amongst ours and other nations for the most part so bungerly and absurdly contrived, as nothing more," and recommends a circular form of needle. From this we see that improvements were being considered, and in 1750, Dr. Govan Knight describes a needle made of two pieces of steel bent in the middle, and united in the shape of a rhombus. Dr. Knight recommended thin straight steel bars, suspended edgeways, a plan which was soon adopted, and is even now in use.

The advent of iron vessels marks an epoch in the compass, and soon called for the energies of scientific men, foremost among whom stands the late Astronomer Royal, Sir G. B. Airy, and A. Smith, the former of whom investigated and invented mechanical correctors, and formulated the laws which govern the magnetic state of vessels, and in Sir William Thomson's (now Lord Kelvin) compass we find almost perfectly realized the practical application of these mechanical correctors.

THEORETICAL.

It is found that the greater part of magnetism is contained on the surface of a magnet—a most valuable circumstance, and one which has been only recently taken full advantage of in the construction of compasses. It is an extraordinary fact that the magnetism of the earth is separated, and various hypotheses have been put forward to account for it. Of these I will only mention two. Biot supposed the magnetic nature of the earth to be such that it might be represented by a magnet at the earth's center, having a length small in comparison to the earth's radius, and making an angle of about 20° with the axis of rotation. Barlow, on the other hand, accounts for the phenomenon by supposing that currents of electricity are continually passing around the earth from east to west. The resulting action of the magnetic needle, supposing either of these hypotheses to be true, will be practically the same.

If a magnetized needle be suspended so as to freely move in any direction, it will be found that in certain places it will assume a perpendicular position, and in other places a horizontal position, and between these places will have various angles of inclination. The places where the needles dip perpendicularly are called the magnetic poles, and the place where the needle remains horizontal, the magnetic equator. The position of the N. magnetic pole was reached by Commander (after Sir James) Ross, in 1831, its position being lat. 70° 5' N., long. 96° 43' W. The same navigator nearly reaching the S. magnetic pole between 1839-43, its position being deduced from observations as lat. 73° 30' S., long. 147° 30' E.

We are indebted to Humboldt for first calling attention to the international importance of establishing stations for regular observations of the earth's magnetism, of which the most celebrated was that at Gottingen, under the direction of Gauss and Weber, to whom we owe the whole system of observation and most of the delicate instruments used. From the observations taken in various places, maps have been constructed showing the positions of equal dip connected by lines called isoclinic lines, places of equal variation by lines called isogonic lines, and places of equal force or magnetic intensity by lines called isodynamic lines. These forces are continually changing, there being a secular movement, small diurnal and annual fluctuations depending in some manner upon the sun's influence, and still smaller fluctuations depending on the moon, besides the occasional disturbances known as magnetic storms. So rapid is the change in the variation in some places that serious errors may arise in steering a course unless the change is carefully attended to. There are also places which are apparently local foci of magnetic disturbance—a fact which has been well known to sailors for a long time, but has only recently been placed on a sure footing.

We will now consider the effect the magnetism of the earth has upon iron and steel, the materials of which vessels are constructed. This effect appears to have been first noticed by a Frenchman named Dennis, as long ago as 1666. In the first place it is necessary to see the difference between "soft" and "hard iron." In the soft iron the magnetism changes with change in position, the change taking place with the greatest rapidity; in the latter it does not, becoming practically permanent; but the induced magnetism can be fixed in soft iron by the simple method of hammering it. For instance, take a piece of iron rod, hold it in a line with the magnetic meridian, and the end which is pointing northward becomes—through the induced magnetism of the earth—a magnet, having magnetism of an opposite nature to that of the north pole of the earth, that is to say, it will repel the north-seeking end of the compass needle; if the rod be held in the line of total force the effect is increased. Now reverse the bar, and the same effect is produced with the other end. If, however, the bar be hammered when held in either of these positions, the magnetism becomes permanent, and the bar is to all intents and purposes a magnet having a north and south pole. If now the bar be again reversed, and again hammered, the amount of magnetism will be reduced, and its attractive power will not be so great. From this you will quite understand that when a vessel is built she becomes a huge magnet from the induced magnetism being fixed by the hammering going on all over her; the magnetism will be distributed according to the direction of the fore-and-aft line with the magnetic meridian. From the experiment with the iron rods, it will be readily seen that it will be advantageous—after the ship is launched and while being finished—to place her fore-and-aft line in a direction opposite to that in which it was while building, as by this means the loose magnetism—if I may so term it—is knocked out.* Attempts have been made to demagnetize vessels, but with no success, as could well be imagined.

After a vessel goes to sea, it is found that there is still some slight diminution in the permanent magnetism, and this diminution would continue to go on very slowly were there not other causes at work to effect slight changes in the vessel's magnetism, and which require constant vigilance on the part of those on board to check. For instance, if a vessel be kept long on one course, the battering of the waves will affect temporarily her magnetic character, and when the course is altered care should be taken to allow for this, although the effect produced may be quite transient. The permanent magnetism of the ship produces the greater part of the semicircular deviation, which is expressed by the coefficients, B and C;† B representing the fore-and-aft magnetic forces of the ship, with its zero effect when the ship's head is north or south; and C, the transverse force, having its zero effect when the ship's head is east or west. The horizontal masses of soft iron in the ship as girders, etc., produce the quadrantal deviation expressed by the coefficients, D and E, and have their combined greatest effect on the inter-cardinal points. The coefficient, A, is always small in amount, and is generally due to some defect in placing of the lubber's line, or may be due to compass being placed too near some mass of iron. If it is large in amount, rigorous investigation should be made of the cause, and steps taken to remedy it.‡ Changes in the nature and distribution of the cargo below decks should be taken into consideration, though, as rule, its effect on the compass is likely to be very small.

When vessels are being fitted with the electric light, care should be taken about the position of the dynamos and the leading of the wire. As a general rule, no dynamo should be nearer to the compass than 60 ft., nor should any main wire pass closer than 20 ft.; and it is advisable that the hull should not be used for the return current.

For all practical purposes, it is quite sufficient to determine the approximate coefficients, A, B, C, D, and E. From these, the probable changes of the deviation may be predicted very easily, and are often useful as giving an idea beforehand of the nature of the alteration on change of geographical position.

A vibrating needle will be found a useful adjunct, as the magnetic ratio between the position of the compass in the ship and a place on shore, free from all magnetic influence, can easily be determined, and the directive power of the compass needles determined.

The Sir William Thomson deflector is designed to carry out practically an idea proposed nearly 50 years ago, by Sir E. Sabine, for the determination of compass errors, whether at sea or in harbor, without the aid of extraneous objects, and can be used for determining all the coefficients except A. The instrument is very ingenious, and would be a valuable addition to any ship's outfit; but I am afraid its use in practice would have to be entirely confined to times when the ship is in harbor, as few would care or should interfere with their compasses while the vessel was in motion, unless the sea is perfectly smooth.

PRACTICAL.

When a vessel is designed, the position of the compass§ appears, in a great many cases, to be about the last thing thought of, whereas it ought really to be one of the first considerations. I do not think I am overstating the case when I say that the constructor should have in his mind the position of the compass in the earliest stage of construction, which position should be checked when the vessel is completed by observations with the vibrating needle.

I am convinced that as many of the bad courses steered with disastrous results to ship and crew

* Abstract of paper read before the Shipmasters' Society, March 18th, 1892.

* The general effect of the ship's magnetism is to reduce the directive power of the compass needles.

† The remainder of the semicircular deviation is caused by soft vertical or inclined iron, and is subject to alteration through change in geographical position.

‡ In a badly designed vessel, the effect of superstructures near the compass may be so great as to entirely mask the effect of the permanent magnetism.

§ Throughout this paper the standard compass is implied.

are due to the inaccessible position of the compass, preventing continual checking of the steering of the ship, as are due to undetermined errors in the compasses themselves. One has only to walk through the docks to see the position in which compasses are placed to verify this. I can only say that the navigation of such vessels must be very rough indeed. Even in the case where a master may find his compass badly placed, he may often remedy this himself by moving it, a few inches even making a great difference, and increasing the directibility of the needles considerably. For, while the attractions and repulsions of magnetic masses are inversely as the square of their distance, the attraction between a magnetic mass and an induced magnetic mass, which is the product of these magnetisms, will be inversely as the fourth power of the distance,* so that it is easy to see that moving the compass only a very short distance may be of considerable advantage.

We have now to consider the compass itself, and here again we find the greatest diversity. One of the most frequent causes of bad instruments is the practice of allowing cost to enter into the consideration of their purchase. A compass cannot be depended upon unless it is of the best manufacture. The pivot should be made of natural alloy of iridium and osmium, and the cup in which it works of sapphire or ruby, which itself should be examined before fitting, as the nature of the material is no absolute guarantee of its freedom from cracks, etc. From the ease with which the card works on the pivot will result a compass card which will not "hang." This may be tested by vibrating the card and noting if it always returns with the same degree opposite the lubber's line, etc. The pivots and caps should be examined carefully with a magnifying glass at least every three months, for possible flaws; and should anything of this sort take place, a spare card should be shipped, and no attempt made to remedy the defects except by a skilled workman. The change in the deviation should, of course, be attended to in such a case.

Sometimes, when the ship is rolling heavily, the compass will be found to be very uneasy. This may be due to the change in magnetism owing to heeling error, but is more probably caused by the isochronism that exists between the periods of the vibration of the needle and "swing-swang" of the ship, and it is then advisable to change the card for one having a different period. As a rule, cards having a long period of "swing-swang" behave best in heavy rolling.

The demand for cheap articles has flooded the market with a lot of rubbish of the most dangerous description, and I think shipmasters should take steps in the matter to ensure at least that their standard compass is a thoroughly good one, and that it fulfills the conditions pointed out.

There is another matter masters should also satisfy themselves on, and that is the ability of the men employed to adjust their compasses. As a rule this is done well, and from their experience those employed are able to adjust the compass in a satisfactory and trustworthy manner, and very quickly; whereas a master, with his many other duties, just at the last moment is not able to attend properly to this important question; but he should take the earliest opportunity of verifying the results given him. The general custom of swinging a vessel only one way is rather faulty, and when there is time it would be of great advantage to swing the ship both ways and take the mean of the results.

Those who have thoroughly mastered the theoretical considerations connected with the compass will be able, where it is necessary, to shift their adjusting magnets in a correct manner, when making considerable changes in geographical position; but this meddling with magnets is to be deprecated, unless the master has at his fingers' end the effects they have on the compass needles. The whole secret of the adjusting of the compass lies in the correction of a force by the application of a similar force in a diametrically opposite direction.

Care should be taken in cleaning the glass cover to the compass bowl, as it is quite possible to set up a temporary attraction between the glass and the card, which might lead to mistakes in the setting of a course.

The lighting of the compass at night time is often a source of considerable trouble—lights burn low or go out, often at critical times, oil overflows or candles melt, and many other inconveniences arise. Binnacles have been fitted so that the card is illumined from below, and it certainly would seem to be by far the best plan. The amount of light required is small, but it should be steady and certain in its action, and the amount of illumination might easily be under the control of the "officer of the watch" without removing the lamps.

The marking of compass cards from 0° to 360°, instead of as now in the different quadrants to 90°, would, I think, be a step in the right direction, and would simplify the application of compass errors.

* Airy, "Treatise on Magnetism."

PHOTOGRAPHY OF COLORS.

In the last number of the *Moniteur de la Photographie*, referring to the so remarkable reproduction of a spectrum obtained by the Messrs. Lumiere, by the method of M. Lippmann, we said that everything was endangered by the admission of the least trace of white light, as this would darken the entire intervening screen and consequently suppress it. We asked ourselves how would it be possible to prevent this injurious intervention. In the course of our experiments on polychrome projections with the aid of three lanterns, we conceived the idea that if the polychrome image obtained on the screen were projected in a camera on a sensitive plate arranged as is that of M. Lippmann, we would obtain in this manner a polychrome image formed of composite colored radiations, without being hindered in the experiment by white reflected light. In fact, the luminous rays of the three lanterns are filtered through three prints, which are veritable sieves with unequal meshes; moreover, they pass through three mediums of different colors, which suppress all white light except that pertaining to that local part of the image where should be produced the effects of the whites. In these conditions the experiment may be attempted, and we do not see why, if the sensitive film possesses the suitable qualities of translucence, we might not arrive at the desired arrangement of an intervening screen, giving exactly the mixed vibrations and the respective length of waves suitable for communicating to our eye the sensations of the colors corresponding to the original. These sensations, in a word, would be produced by a vibration analogous to those resulting from the direct action of the natural colors on our visual organ. We may be told that the method would be very indirect, since it would be necessary to first obtain three negatives of a subject in different conditions; afterward project the three positives made from these negatives, in three distinct lanterns, through lights of three different colors, on a sensitive plate to be developed and fixed in the ordinary manner. We will answer that we must first reach the goal, even if we have to do so indirectly; if we reach it, we will find a method afterward to shorten the road and to attain more directly the final end.—*Leon Vidal, in Moniteur de la Photographie.*

SPEAKING PHOTOGRAPHS.

Some time ago, *La Nature* reproduced a short note to the Academy of Sciences, in which I gave a summary of my first experiments in the analysis of the motions of speech by means of a series of photographs obtained by Mr. Marey's method. I stated also that

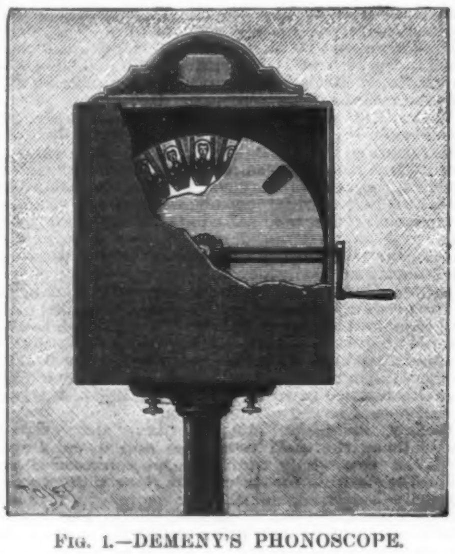


Fig. 1.—DEMENY'S PHONOSCOPE.

I had entered upon a synthesis of such motions and had succeeded in giving an illusion of them.

The first experiments, despite their imperfection, allowed me to foresee a possible success, and the result to be obtained was worth the trouble that it cost. The improvement had to be in the quality of the photographic images and the best adaptation of the synthetic apparatus. The selection of the objective, and the illumination, better directed and intenser, sensibly improved the negative images, while permitting of their being taken of larger size and with all the sharpness desirable. I have thus been able to obtain, very distinctly, the image of the tongue when the mouth is open. The only precaution to be taken is to so manage, if several luminous sources are employed, that there shall not be several too different shadows produced, as this would lead to false interpretations.

I have not yet succeeded in obtaining satisfactory negatives by artificial light. Concentrated sunlight is the only light that I have succeeded with. The reason is that it is absolutely necessary to reduce the time of exposure of every image if it is desired to catch the rapid motions of the closing of the lips. If we take a small number of successive images in a second, we run the risk of allowing of the escape, between two images, of an interesting phase of the motions of the lips. Although I have taken about fifteen images per second, it has nevertheless happened that the closing of the lips chanced to be precisely in the interval that separates them, and, in order to avoid this inconvenience, it is prudent to take several different series of the same phase. It is probable that the images of one series will complete the other.

Such precautions being observed, I have made disks that carry the positive images of the speaker upon their circumference. These I have afterward placed in the synthetic apparatus. All apparatus designed to produce the illusion of a motion by means of images representing the successive phases of it are based upon the same principle.

They consist in making the analytical images pass rapidly in succession before the eye. The essential conditions to be fulfilled are a continuity in the visual impression, an adequate illumination, and a distinctness of the impression perceived.

The visual impression will be continuous if the images are numerous, and if they substitute themselves for each other in an interval less than the duration of the retinal impression. This condition requires that there shall be not less than from ten to twelve substitutions per second. In reality, still more images are necessary, in order to prevent discontinuity and to obtain the smoothness that we observe in the natural motions.

The great difficulty is to substitute one image for the other so that it shall occupy a relative position exactly conformable to reality. The least error in registering is a cause of jerking motions that are disagreeable to the eye and are prejudicial to the illusion.

The distinctness of the impression depends upon the sharpness of the images and still more upon the motion that the image has while it is being looked at. If we employ continuously revolving disks, that is to say, disks on which the images are always in motion, we shall be obliged to greatly reduce the time of exposure or impression.

In employing times of exposure varying from $\frac{1}{500}$ to $\frac{1}{1000}$ of a second, we obtain sufficient sharpness. But this reduction in the time of exposure works to the detriment of clearness, at the expense of the intensity of the luminous impression. It is possible, it is true, to increase the intensity of the illumination, but from the standpoint of the perception of the luminous sensation, a very intense excitation which acts for a very short time does not give so vivid an impression as an excitation not so strong, but of longer duration. The solution of the problem is confined within very narrow limits, between which there is a want of light or discontinuity in the impression.

Plateau's phenakisticope is the father of all zootropes, and to it we owed many hours of pleasure in our childhood. The cylindrical zootrope is merely a transformation of it. In these two instruments the eye sees each image through a slit in the cardboard upon which the images are figured. The relations between the number of images and the number of slits produces the illusion of the displacement of the image upon the paper. In the motions in place, on the contrary, the slits and images are equal in number and correspond to one another. The images seen in zootropes thus constructed have the two great defects of being dim and distorted.

In the praxinoscope, the objects are seen in a series of mirrors forming the faces of a trancated pyramid and situated in the center of the apparatus. The images are then clearer, and without distortion, but the passage from one to the other does not take place without a sort of skipping that it is difficult to avoid.

Messrs. Muybridge and Anschutt likewise have constructed some very fine apparatus illuminated by a projection lantern or by an electric spark.

I have very recently got up an instrument especially designed for giving the illusion of the motions of speech and of the plays of the countenance, although it may be used for the synthesis of all motions. I have named it the "phonoscope." It has the quality of being illuminated by transparency and of allowing the images to be seen in a time so short that the *flou* of velocity is insensible to the eye (Fig. 1).

The artifice employed consists in giving the illuminating disk, which is provided with a single aperture, a relatively great velocity with respect to that of the image. If we look in the phonoscope at the successive photographs of a subject who is speaking, we see in a striking manner the portrait become animate and move the lips (Fig. 2, No. 1). The effect may be increased by looking through a magnifying glass. It is possible thus to project the successive images upon a screen by adapting the apparatus to an ordinary projection lantern (Fig. 2, No. 2).

With an apparatus arranged for observing through transparency we have not been able to repeat the experiments of reading from the lips made before the director of the National Institution of Deaf Mutes,

Fig. 2.—No. 1, DEAF MUTE READING FROM SPEAKING PHOTOGRAPHS IN THE PHONOSCOPE. No. 2, PROJECTION OF SPEAKING PHOTOGRAPHS BY MEANS OF AN OXYHYDROGEN LAMP.

who brought us in person three of his pupils. One of these children immediately read the photographed phrase; but as the photographs formed a continuous series, the beginning of the phrase immediately followed the end of this same phrase. The deaf mute thus had no precise indication as to the place where he was to begin the reading, and he could divide the phrase at any point whatever. This is what happened to his companion, who, for this reason, slightly changed the sense of the reading. I propose to remedy this inconvenience in the construction of other disks.

The sincerity of the reading cannot be put in doubt. The pupil had no preliminary knowledge of the phrase pronounced, and the reading aloud that he did was absolutely regulated with the motion of the crank by means of which I revolved the image disk. If I retarded the rotation, the child retarded his utterance, and if I stopped, he stopped. The same words were pronounced at the same positions of the winch, and they might have been inscribed upon a dial and the absolute coincidence have been found. In a word, I played the deaf mute like one plays the hand organ. I played the bad joke of revolving the winch backward, and reading was then impossible.

This experiment, at which were present the Censor of the School of Deaf Mutes and Prof. Marichelle, of the same institution, both perfectly competent in the teaching of reading from the lips, gives me the hope that it will be possible to derive some utility from this process of reading.

Since the illusion produced by the apparatus corresponds to a fixed interpretation of the sound emitted, is not there reason to believe that, in properly selecting the examples, the professor of reading will be able to obtain an exact knowledge of what his pupil sees and how he interprets motions stereotyped in the phonoscope, and which he may study himself in the isolated photographs?

It is useless to dwell upon the attractiveness of these researches, which are also an example of the utility of zootropic apparatus for the education of visual perceptions.

Those who may not be convinced of their utility as regards reading from the lips will perhaps be interested when it becomes a question of reproducing the expression of the countenance. If it is possible to make a photograph speak to the point of reading from its lips, it will be possible also to animate such photograph and give it all the plays of the countenance.

How many people would be glad if they could see again the living features of a departed person for a few instants!

The future will replace the immovable photograph fixed in its frame by the animate portrait to which, by the turn of a wheel, life may be given.

The expression of the countenance will be preserved as the voice is preserved in the phonograph. It will be possible, even, to add the latter to the phonoscope in order to complete the illusion. Then photography will have satisfaction of the criticism that is often made of it of being cold and of catching but a precise instant of life.

The expression of the face is considered by some as something that cannot be caught and as inaccessible to the exact processes of analysis. We shall hereafter do more than analyze it, we shall make it live again.—*G. Demeny, in La Nature.*

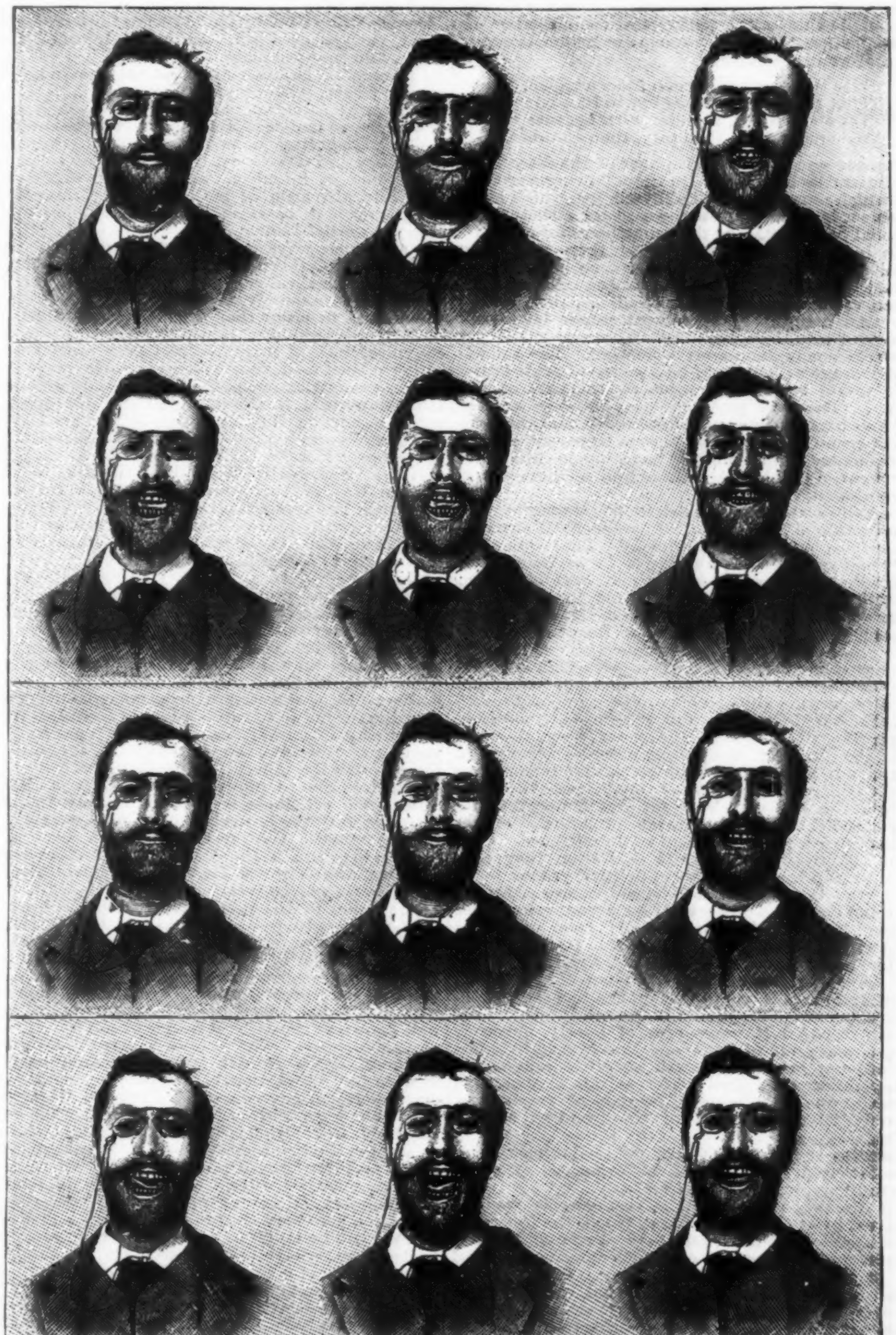


FIG. 3.—SPECIMEN OF SPEAKING PHOTOGRAPHS—PHOTOGRAPHY OF THE WORDS, "VIVE LA FRANCE!"

RECENT RESEARCHES IN CRIMINOLOGY.

By DR. EUGENE MURRAY AARON.

IT has recently been said by a prominent anthropologist that our modern civilization has so improved that it exceeds the natural capacity of many individuals who live in our midst. Modern civilization represents the last and final effort of the individuals who are the best equipped. Many persons who now might be regarded as more or less criminal would have been esteemed honest if they had been destined to live in the primitive civilization of ancient times when our ancestors formed the barbaric races of Europe. It cannot be denied that we are not born to the high moral standards now set up for our guidance. We are, on the contrary, born with the crude moral perceptions which have come to us through the many centuries of semi-barbaric living, and our fitness for living in accordance with the teachings of these last decades is largely dependent on our environment and training. It may well be said, in the words of Lacassagne, that "society has no criminals except such as it merits." In other words, the care taken by society to prevent criminal development and propagation is not commensurate with its desire to formulate laws based on its advanced ideas of what constitutes crime. So it comes that the laws made by the very respectable and powerful minority are far in advance of the inborn tendencies or acquired powers of the vast majority of mankind. Naturally, therefore, the criminal or, in this light, least capable man is the victim by that much of what thus becomes to him class legislation, and, in the words of M. Alimena, "the criminal is produced by the same processes as are employed by stock raisers to rear new races as an improvement of the present races." By driving them together in mutual sympathy and for mutual protection society places a premium on the interbreeding of criminals, and thus assures the perpetuity and intensification of the breed.

It is this line of thought that has made the work of the criminal anthropologist of vital interest in recent years to all who are, however remotely, engaged in watching the advancement made by political science in the amelioration of human misery. It has been clear to many that if men are born criminals, or if they are what society makes them, in either case there is a crying need for radical changes in our criminal jurisprudence. If they are born with a bias toward crime, then in many cases the hospital or asylum is more fitted for their reception than is the prison. If, on the other hand, the manufacture of the criminal class is a matter of education and surroundings, then it is high time that there should be sweeping changes made in both these creative causes. It must be evident to all that at present no question can surpass in importance those which have to do with the pathology of crime.

In Rome, in 1885, there met for the first time an association of delegates from all quarters of civilization, who organized themselves into the International Congress of Criminal Anthropology. Again in August, 1889, at Paris, this association met, and continued with renewed vigor and interest the discussion of many questions of importance. Fortunately an epitome of their proceedings has been given to the scientific world in the annual report of the Smithsonian Institution for 1890,* but unfortunately it has of necessity in that form but a limited circulation. Therefore it has seemed to me to be worth while to give here a brief *resume* of the more salient features of the discussion, with such comments from other sources as may be germane thereto.

Since 1885 it has been apparent that the students of criminal anthropology were divided into two schools, called usually the Italian and the French schools. The first of these, led by Prof. Cæsar Lombroso, with the majority of the Italian students as a following, are firm adherents of the doctrine of the permanence of the criminal type, the physiological as well as psychical differentiation of the class, and all those minor laws which depend from these postulates. The French school, on the other hand, is that in which the majority of the observers from that country are led by Dr. Manouvrier. To them sociological conditions are sufficient to explain the vast and multiform problems of criminal psychology.

During the congress of 1889 the skull of Charlotte Corday, "which belonged, with all guaranty of authenticity, to the collection of Prince Roland Bonaparte," was the main object of contention over which this battle was more than once fought. It was presented as the skull of a criminal born in which the depth of the occipital fossettes was an illustration of a marked characteristic of the type. To which it was replied that such a character could by no possibility signify anything, and that if Charlotte Corday was by this sign a born criminal, "then instead of being a heroine who rid the world of a monster, she was naught but a common, vulgar, impulsive murderess." This was a veritable battle royal to which the leading lights of the science throughout civilization contributed from their vast store of knowledge. Yet, it was more than once apparent that the differences between these schools were more those of argument than of actual fact. For it was plain that there was a common ground on which all could meet, as will be seen later on.

In opening the case for anatomical and physiological differentiation on the part of the criminal class, Prof. Lombroso quoted the recent investigations of Batt, Brunati, Gonzale, Marro, Pinero, Tonnia, and Verga as upholding his conclusions, which had already been fully set forth in his recent writings.† In several particulars he found differences existing between the criminal of occasion and the criminal born. In the former he found "his sensibility less obtuse, his reflexes less irregular, the anomaly less frequent, especially in the skull." Certain of the characters of the criminal born, however, were always present, "such as the blackest hair in the servant who is a thief, awkwardness more frequent among swindlers, and that all are more governed by impulse." In commenting on his examination of the photographs taken by Mr. Francis Galton, Prof. Lombroso spoke as follows:

"I have found in eighteen skulls of condemned persons two types which resemble marvelously, and with an exaggeration which is evident, the characters of the criminal and approaching those of the savage. Frontal sinuses well marked, cheek and jaw bones very large, orbits large and distant, an unsymmetrical face, the nasal overture of a pheleiform type, and the lemurian attachment of the under jaw. The other skulls of the swindlers, thieves, and robbers gave me a type less precise, but the want of symmetry, the great size of the orbits and the prominence of the cheek bones were well marked, though less than in the former cases." In comment, M. Bajenoff stated that his cephalometric studies had led him to believe that "honest men had a larger frontal development, while the criminals were better developed in the parietal and occipital portions of their brain or skull."

In introducing the question of "the organs and functions of sense among criminals," Dr. Frigerio announced that he had, in a large series of examinations among the criminal and non-criminal classes in Italy,

* *Criminal Anthropology.* By Thomas Wilson, LL.D., Smith. Rept., 1890, pp. 617-686. Washington, 1891.

† The latest presentation of Prof. Lombroso's views will be found in the following from his pen: *L'Anthropologie criminelle et ses recents progres.* Paris: F. Alcan; and *Der Verbrecher in anthropologischer, aerztlicher und juristischer Beziehung.* Hamburg, I. F. Richter.

encountered a predominance of the chestnut colored iris among criminals, and a considerable proportion of blue among violators or offenders against public morals. Visual acuteness he found much more developed among the criminals; while the sense of smell was inferior, as was also the sense of taste. On the other hand, however, the sense of hearing among 280 criminals examined in prisons was found to be abnormally acute. Of this faculty Dr. Frigerio says: "It is without doubt true that the disuse of one sense will serve to sharpen another. As is the sense of touch among the blind, so is the sense of hearing among those prisoners who are condemned to silence. . . It has come to be known definitely and certainly that they communicate with each other by means of a tapping or striking upon the wall or other substance. This sort of telegraphic communication may be likened unto the old Morse alphabet. . . Thus it happens that a prisoner will continue his work even in the presence of the guard who is watching him, yet by the strokes which he may make in his work he can communicate with the other prisoners who may be within earshot, and it does not seem to make much difference to them whether the surroundings are in silence or amidst a deafening noise. . . Although the guardians wore slippers shod with cloth or felt, intended to enable them to walk noiselessly, yet every criminal detects the difference in the step of the various guards so as to tell which one is approaching. . . If the sharpness of hearing among criminals is engendered by the inertia or disuse of the other senses [such as taste and smell, which were somewhat obtuse], we were unable to find any physiological or anatomical evidence of it in the brains of those whose autopsies we made."

Other characteristics were referred to by Prof. Lombroso and others as being common to many criminals; among these hernia was stated to be prominent, and the "role of ptomaines in criminal manifestations appeared certain." Ottolenghi found facial wrinkles more marked in criminals; especially was this so in the case of the naso-labial wrinkle, which he regarded as a characteristic. He had also remarked a great retardation in both baldness and gray hair in the criminal classes. Lombroso stated that in criminals the average temperature was much above the normal. An analysis of the urine of the born criminals yielded a larger proportion of phosphoric acid and less of azote. Dr. Brouardel related his observations made on an epileptic woman in his service; her urine contained a ptomaine, which when injected into a frog produced the same physiologic effects as strychnine, *i. e.*, convulsions. Lombroso also called attention to the repeated cases where epilepsy was accompanied by a total absence of the moral sense. This, in his opinion, found as it is "with erethism or exaggerated sensibilities, explains how some persons, criminals because of their passions, have many times an unconsciousness of their own criminal acts." It is principally among those suffering from alcoholism, hysteria, and monomanias that epilepsy became a marked factor in the criminal insane. Commenting on these statements, M. Benedickt gave it as his opinion that "criminals were sick men either in body or spirit; and if one examines the exterior morphological signs to explain and account for the existence of crime in the conduct of a given man, it was equally necessary to investigate the molecular trouble in his cerebral structure." Madame Clemence Royer called attention to hybridity as a hitherto unconsidered factor in the genesis of crime. The mixture of races, the mixture of blood of different races, one of which was usually if not always inferior, was, in her opinion, a factor of prime importance.

In opposition to all theories that held the criminal to be anatomically or physiologically differentiated, Dr. Manouvrier was most active. He pronounced the theories of Lombroso regarding the anatomical characteristics of criminals to be "but a recitation of the exploded science of phrenology." While admitting that such characters were present, he declared them to belong to the moral and criminal classes alike and of no diagnostic value whatever in the study of "criminology." They were but structural or functional differences, while crime was a matter of sociology. "If Lombroso's theory, that the man was born a criminal, was to be taken as the rule, then it must be universal, and that men thus born inevitably committed crime. If it be the rule, then it must operate in all cases. That it did not so operate proved that it was not the rule, and therefore he concluded the proposition [sic] of anatomic characteristics peculiar to criminals did not exist."

Again he said, "There are honest men affected in all the unfortunate and much to be regretted ways suggested by Signor Lombroso—epileptics, imbeciles, degenerates, and even the vicious and inferiors of all classes; while those who have been classed as honest men are capable of becoming criminals of the darkest dye." M. Tarde, taking prostitutes as a sample, stated that "an honest woman presented the characteristics ascribed to the criminal woman as described by the Italian school." Prostitution he considered "the occasion and not the offense;" it would then seem that to the French school the ethics of prostitution were those of environment and not those of pathology. Yet the problems resulting from nymphomania and other forms of sexual psycopathy are not to be thus accounted for. Benedickt declared that the criminal was possessed of no diagnostic stigma or mark by which he can be known from others; there may be signs of defective organization, but they are equally those of the epileptic or the insane.

Undoubtedly the most unanswerable point urged against the holdings of the Italian school was that made by Manouvrier when he asked, "Who form this class of honest and virtuous men that furnish the standard by which the criminal classes are to be judged?" As he pointed out, there may be among them the idle, vicious, brutal, and the evil disposed, who, if they have so far not fallen under the ban of the law, would still be classed with the non-criminal classes. The Bardsleys, Marshes, and Deemings of society might, in this view of the case, be classed anthropometrically with the morally exempt to-day, and to-morrow, when their crimes had found them out, they would furnish figures for the other side of the criminological ledger. This contention, though obviously most pertinent and important, was not replied to by any member of the congress.

If the Italian school appeared didactic in setting forth its postulates, their opponents were equally so in their espousal of the cause of the sociological genesis of crime. M. Lacassagne gave it as his opinion that "it is society that *makes* the criminals. Society has only the criminals it merits. Criminality was above all a social question. . . It is not atavism, but the social surroundings, the social condition, which make the criminal. M. Pugliese considered crime "a social anomaly, and a consequence of a failure of the criminal to adapt himself to his social surroundings." Manouvrier asked, "Who can say what may not become of the man who has a sound body if he be subjected to the continued pressure of adverse sociologic surroundings?" To him it was "the infantile life, familiarity with vice and crime, the surroundings, the want of moral training, sociological conditions," which produce the criminal rather than anatomic characters. . . . "It is idle," he continued, "not to recognize, in addition to the imperfections of human nature, the pernicious influence that is exercised by the evil education, the evil examples, the natural or factitious needs, the seductive occasions, the improper liasons, the repugnance to labor, the pleasures of idleness, the apparently natural willingness to eat the bread and enjoy the fruits of another's labor, or the satisfaction of a former escapade which brought profit and went unpunished."

"Vice is a monster of such hideous mien,
That to be hated needs but to be seen:
Yet seen too oft, familiar with her face,
We first endure, then pity, then embrace."

In further comment on this phase of the discussion, Manouvrier called attention, in the following words, to a fact which must be admitted by all, yet which has a very direct bearing against the case for structural or functional peculiarities as the prime bases for crime:

"We have still to consider that there are many physiologic peculiarities which become good or bad qualities according to the circumstances, and these circumstances are simply the surroundings, the environment. An amorous temperament might be highly appreciated and complimented in one case and yet become extremely dangerous in another. The audacity and courage which might be a source of pride in the soldier would become execrable on the part of the robber. . . The best mechanic may become a most dangerous bank burglar or counterfeiter, and this eminence of crime is attained because of apparently natural excellences which might have made him, and which went so far toward making him an honest and successful man."

Rabourdin's wolf was alluded to by Manouvrier as an illustration of the effects and tendencies of environment in this problem in sociology. That animal its master had succeeded in training to be an honest and respectable member of the sheep fold, refraining from attacking its charges, but contenting itself with its regular meals. "The regular meal to the wolf played the same role that the daily income does to the man, by the grace of which many persons who might easily become criminals pass their days with high heads in society and enjoy the confidence of their neighbors with a reputation all their lives of being honest men." M. Laschi stated that the most revolutionary cities of Europe, like Paris, Florence, Geneva, were those in which the greatest genius and most vivacity of thought were manifested. Though this is obviously an example which would prove too much, from the point of view of the Italian school, yet Drs. Brouardel and Motet insisted that the presence of political crimes was due to an inferior average of intelligence. Fanaticism, impressionability, and exaltation they considered to be principal factors in political crimes.

The case against the sociological causes as the efficient and only ones wherewith to account for these problems, beyond what has already been quoted as said in support of the position of the Italian school, was thus tersely summed up by Prof. Ferri:

"If crime be the exclusive product of the social surrounding, how is one to explain the fact known to us every day of our lives, that in the same social status and under equal circumstances of misery, poverty, and ignorance, out of each one hundred individuals sixty are not criminal, commit no crime, and out of the remaining forty, five prefer suicide to crime, five become insane, five become beggars or vagabonds, and only twenty-five out of the hundred become criminals."

Returning to the discussion of political crimes, Prof. Lombroso cited M. Taine, the historian, as referring them to the realm of political epilepsy.

This discussion between the two schools was reawakened by several of the topics before the Congress, but as has been already said, there appeared to be a common meeting ground on which the champions of each party could camp in harmony. This was well defined by Prof. Ferri, who said that crime "was a sort of polyhedron of which each person saw but a special side. . . . Lombroso brings to light the biologic side of crime; Drill and Manouvrier showed the social; Pugliese, the legal view; Tarde presented the physiological side, and Moleschott and Brouardel declared crime to be a phenomenon at once biologic and social." Tarde, while holding that there were no anatomic characteristics of the criminal class, nevertheless believed that "there were organic and physiologic predispositions to crime. The function," in his opinion, "made the organ, and the nerve would model the bone; as the river determines the valley, so the crime makes the criminal." Commenting on his experiments with the epileptic woman, already narrated, Dr. Brouardel stated that "leucomainic toxique found in the veins of the insane or the melancholy results from troubles in general nutrition. Are they cause or effect?" he very pertinently asked. Drill pointed out that man was an extremely complex creature, his life depending on his environment, education, training, companions, and other like causes. "Whatever there might be in the physical or anatomical characteristics of a man which would point toward his crime or the possibility of its commission, that each of these elements entered into and became a factor, and were each and all of them to be considered in deciding this question." Lacassagne conceded that social influences "might modify the organic characteristics and thus create these anatomic anomalies which were relied upon by the Italian school."

These statements of the interdependence of the organic and sociologic factors in crime production were undoubtedly "the sense of the meeting," and outlined an intermediate territory between the opposing camps of Lombroso and Manouvrier, in which even these extremists could dwell at peace with each other. During these most pregnant discussions classifications of crime and the criminal class were announced that will be of interest here. Ferri divided the criminal classes into five divisions, viz.:

The born criminal;
The insane criminal;
The criminal of occasion;
The criminal of passion;
The criminal of habitude.

The first of these, the born criminal, Dr. Magnan divided into three classes, as follows:

Intellectual faculty predominant; morals defective.
Morals predominant; intellectual faculties defective.
Apparent equilibrium between morals and intellect; but usage defective, as in application, effort, emotion, etc.

Supplemental to these classifications Manouvrier proposed the following classification into three divisions:

Inexplicable Crimes: Viewed from the normal standpoint, such as are committed by the insane, epileptic, idiots, and monomaniacs.

Crimes of Delirium: Such as are due to anger, alcoholic frenzy, jealousy, and fear.

Crimes of Intention or *sang froid*, or such as were deliberate, of malice aforethought, or premeditated.

While relegating the first two classes to the realm of pathology and teratology, it was only the latter class, the crimes of intention, he asserted, which should claim the attention of a Congress of Criminologists. It was evident, however, that this opinion was not shared by other leaders in the Congress. For it was to the abnormal physiological or anatomical condition that most attention was given, and rightly so it would seem. The medical membership in such an association would be an anomaly, a useless limb, if it were only the normal in crime that was to be considered. It is its very abnormality, which each year's experience convinces us is of more frequent occurrence than has hitherto been held, that makes crime the proper study for an association composed of legal and medical men. How important is this study of the abnormal, how much it may in time teach us of the need of legal emendation and pathological change, the recent words of Professor Horatio C. Wood best show. In a paper entitled "Neuropathic Insanity in Relation to Crime," read in May, of this year, before the State Medical Society of Pennsylvania, he has this to say:

"Neuropathy means diseased structure of the nervous system, and may be inherited or acquired; that, as the result of inheritance, an improperly developed brain may produce an insanity of character as positively as it may produce an insanity of intellect, and that this insanity of character may be so rooted in structural nervous disease that it cannot be cured. Vice or nervous disease or alcoholism in the parent may produce an insanity of character in the offspring which shall dominate the whole life of the individual, making him a criminal, who is no more responsible, morally, for his acts than is a man who suffers from an inherited gout for his pain. . . . To punish for the purpose of revenge such a criminal is unchristian, to punish with the object of reformation of the criminal is hopeless, and to punish with the hope of deterring other such criminals is useless. Society has for its bounden duty the protection of its sane members from these criminals; the present system of shutting such persons in prison, letting them out and reincarcerating does not afford protection. *During their periods of freedom they breed criminals.*"

The italics in this quotation are mine. I have used them to accentuate what seems to me to be the most important factor in this whole problem of the decrease and obliteration of the abnormally immoral impulses. The statistics of criminal descent, whereby the remarkable and startling tendency of criminals to breed criminals has been proved beyond peradventure, are too well known to the general reader to call for more than passing mention. The right of society to take life from the homicidal neuropath, after his mania has shown itself in the destruction of human life, is universally granted by all governments. Professor Wood carries that right even further when he says: "Society has the right to put to death such homicidal neuropaths or lunatics (human tigers), whose maintenance involves death or injury to all about them." There are few medical men yet willing to follow the professor this far, probably still fewer in the legal profession, yet there is a half-way ground on which, no doubt, very many could be found to unite. If society may reserve to itself the right to take life from the life taker, or to take freedom of action from him who has indulged in too great freedom of action where the property rights of others are concerned, then, surely, they may, with equal justice, take from the criminal neuropath, who breeds his kind, the power to continue thus to menace the social well-being. It is this branch of criminology, it appears to me, which calls for the most careful and immediate attention. And I do not hesitate to say that, so far as I can judge from extended conversation and reading, a consensus of opinion, taken among the members of the various medico-legal societies in this country at this time, would result in producing a considerable majority who are strongly in favor of the destruction of the reproductive organism in such neuropaths as shall be ascertained to be hopelessly such. That society could ever exist in such a state that they could be so indifferent to their own well-being as to allow a near-by colony of rattlesnakes to breed and increase unmolested is beyond our powers of belief. Yet a human animal equally irresponsible by virtue of his inborn virulence, and a hundredfold more dangerous to the social equipoise, is perfectly free to select one of his kind and produce, as a burden on and perpetual menace to our posterity, an ever-increasing progeny of "human tigers," as they have been well termed. How much longer this state of affairs shall continue as a grim comment on the illogical attitude of lawgiver and sociologist alike only the future action of our medico-legal experts can determine.

The very meager table of statistical results which our delegate to this last Congress, Dr. Thomas Wilson, was able to offer called attention to the fact of our present need of national enactments which shall make

possible not only the gleaning of approximately complete data on all branches of criminology, so far as the State comes in touch therewith, but also our need of legislation governing the rights of medical men to prosecute needed researches. Since 1884, when M. Beltrani-Scalia became its general director of prisons, Italy has ordained the autopsy of all criminals dying in prisons. In this way a volume of statistical information has been accumulated the like of which we have nothing to offer in comparison. Such researches should have for their purpose, as indicated by Dr. Sciammana, the establishment of an international system of comparative statistics. Psychological and clinical researches should be made before the criminal's characteristics have been modified by any protracted period of prison life. These should be repeated before his liberation, if a sufficient time has elapsed in which his idiosyncrasies may have become modified. In each case, where death occurs while the person is "in durance vile," there should be an autopsy performed; and this should be so thorough as to determine, where possible, whether observable abnormalities are due to the pre-eminence of morbid tendencies or are the result of development due to other causes.

So much for the need of advance in the medical branch of this most important department of inquiry. Equally needed are certain modifications in the legal divisions of the subject. As was suggested by Judge Pierre Sarraute, to the juror should be left only the province of passing upon facts of occurrence, questions of law alone to the judge, and questions of psychology and physiology alone to the scientist, who should be a trained criminal anthropologist. As was pointed out by M. Pugliese, the present prosedure is very inadequate. A juge d'instruction or prosecuting officer rarely possesses that special training in the fundamentals of science which alone can fit him for a judicial inquiry into many cases that are sure to come before him. Of this total lack of true system, this learning at society's expense, it has been well said, "the faults and scandal are enormous." Dr. Brouardel combated the idea of making judges only of experts on the rather novel and ambiguous ground that "the responsibility was too great and the result would be unsatisfactory." Unfortunately, he did not explain this sentence. How a scientific training based, of course, upon fitness and the possession of the judicial faculty, which should always be the *sine qua non*, could heighten the responsibility of either the judge to society or of society to the judge, or how it could further complicate or accentuate the present very unsatisfactory methods, it is most difficult to imagine. As bearing upon this subject, the words of Professor Wood may be quoted: "The law should recognize many criminals, including drunkards, as neuropaths, who should become, not the victims of law, but wards of the law, to be isolated in institutions resembling criminal asylums rather than prisons." How can this be safely done, it may asked, while committing magistrates are selected, as they now are, and their ranks are recruited from the present sources?

At present the most prominent utilitarian movement, springing from the study of criminal anthropology, has been that branch of anthropometry which has had to do with the positive identification of the criminal. This has been brought to the greatest state of perfection in France, where, under the superintendence of M. Herbette, chief of the penitentiary system, and M. Alphonse Bertillon, at police headquarters, in Paris, is carried out the system devised by the father of the latter, Dr. Adolph Bertillon, the discoverer of this branch of the science. This system is designed to aid and supplement what in this country is commonly called the "Rogues' Gallery," where a *carte de visite* is supposed to be kept of each ascertained criminal. While even in small towns or in country districts this system is cumbersome and at times very misleading, when it comes to be applied to the requirements of a large city it becomes entirely inadequate. In Paris, for example, there were, in 1889, 100,000 photographs thus accumulated as the result of ten years' watchfulness. Such a collection, to be of real value, calls for both a full face and profile view, and this array, if displayed on a wall in a strip 5 ft. in height, would, it has been estimated, require a space 2,120 ft. in length, which is something more than the outer wall space of the Capitol at Washington. How utterly hopeless a search through this vast accumulation would be in the effort to identify a given suspect, needs no further illustration. Hence a system of classification whereby the time for a given search could be reduced to a minimum was imperatively called for. Such a system M. Bertillon now has in operation in Paris, and, on his visit to this office, Dr. Wilson tells us that he and two others from the Congress found that system so perfect that they were able to identify a given criminal, hearing the description for the first time and being entire strangers to the system, finding the card on which his description was written, and this, he adds, "We did within two minutes."

The system in use under M. Bertillon has for its basis the following classification:

1. Height of the individual.
2. Maximum length of the head.
3. Maximum breadth of head.
4. Maximum length of arm.
5. Length of left hand middle finger.
6. Maximum length of left foot.

This procedure gives six measures, and will, obviously, subdivide a large series of subjects into very many groups. In addition to these, the color of the eyes is used as a non-alterable feature of importance. On this subject M. Bertillon has written his paper, "La Couleur de l'Iris en l'Anthropologie," * which it will be of interest to consult. By the selection of certain arbitrary lines of demarcation in the measurements, as 184 and 189 millimeters in those of the length of the head, each of the foregoing six classifications is capable of three subdivisions. Thus it will be seen that the search for a given photograph and its accompanying verbal description is greatly simplified. When the color of the eyes and such blemishes and characters as wens, moles, scars, and birth marks are taken in connection with these measurements, absolute identification is possible in the great majority of cases.

Anthropometry was first adopted by the Argentine Republic after France. Its adoption outside of a very few of our cities has not been as thorough as it should have been in this country. The instruments with which the measurements are made are simple, inexpensive, and easy of operation. They and the full system are very explicitly described in the report already alluded to.*

If this science of criminology shall have, during the next generation, the encouragement from our institutions of learning, our judiciary, and our legislatures which its great importance entitles it to, it is safe to predict that our grandchildren will be then quite as capable of crime prevention as we now are in the crude and illogical field of crime retaliation.

* *Annales de Demographie*, 1881-2.

* Smithsonian Report, 1890, pp. 672-682.

THE SHEPHERD'S STAR.

THERE is no one who has not, for several weeks past, remarked the admirable star which shines with a brilliant light every evening in the western heavens. Of a luster without rival, the white planet reigns as a sovereign over the land and sea. It can be found by the naked eye, even before the setting of the sun, and several possessors of excellent eyesight are exercising themselves at this very moment in discovering it at noontide, and in following it through the heavens for the entire day. Two readers of this journal write to us that they have succeeded in discerning its phases by the naked eye. At this moment, it has the form of a crescent.

In the midst of the agitated life of modern cities which, especially at present, are sweeping the majority of men into a more or less blinding vortex, the glittering star is observed in the evening, only to be as quickly forgotten; but formerly, in the peaceful quietude of the fields or the ancient cities, when life was truer and less rapid, eyes were arrested longer upon the various spectacles of nature and an apparition such as that which is rendering our western sky brilliant was the subject of all thoughts and of all conversation. The question was asked what this movable star, which seemed to dispute its light with that of the sun itself, could be. It had been remarked that it never gets very far away from the orb of day, and its periods of appearance and disappearance had been explained as due to a motion around the sun. Its splendor, its beauty, its luster, so soft in the vanishing light of twilight, the whiteness of its light at nightfall and its sovereignty in the sky of night, at the hour of rest, of dreams, and of confidences, have insensibly led to this charming star's being designated by the most sympathetic names. Venus was the first star admired, cherished, venerated, and even feared. It is the oldest and most popular of the ancient divinities. From primitive ages, the hour in which it brightens up its limpid aspect was awaited by the *fiancée*, who associated the most beautiful planet with the tenderest feelings of her heart. What eternal but ephemeral vows has not this white star received amid the silence of warm spring evenings, at the hour in which the last breath of perfumed atmosphere glides like a chill through the fields and the woods!

The generation of languages somewhat resembles that of things generally. Words are born from impressions and have personified associations of ideas. Venus very naturally became the goddess of beauty and love, white as the light, as perfect in her form as an emanation from heaven, and, sovereign-like, the star that dominates the world. Near the sun, swifter, more undulating, Mercury was a messenger of the sun on a perpetual travel, with wings on the feet, and, later, god of commerce, of industry, of navigation, of sacred research, and of medicine; Mars, of the red rays, active in his celestial travel, symbolized war, strife, and bloodshed. Calm and majestic in his course along the constellations, Jupiter became the supreme god, managing the general order of the world. And, ever there, pale Saturn, slow and without luster, personified time and destiny. Thus, the very aspect of the stars gave birth to mythology and religions.

The first star set ablaze in the sky, as white as light, as beautiful as the day, divine ray of the first nocturnal hours, how can we wonder that Venus has been personified since the adolescence of the world as the goddess of beauty and love? If some Adam and Eve inhabited the terrestrial paradise, the morning and evening star cannot have failed to strike their attention, and, from mythological times up to our lamentable century's end, in which the wings of Cupid seem to be radically plucked by decadent literature, it is toward her, that celestial beauty, that have flown the first confidences of simple hearts that know how to love. Venus received their incenses, and gave them in exchange the radiation of her light, which fecundates the world and eternizes life.

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Science has not diminished the charm of the evening star. Although mythologic fiction, born spontaneously of the very aspect of Venus, has been dispersed like a thin cloud, astronomical reality is neither less beautiful nor less interesting. We know that this bright planet is a world like our own, almost absolutely the same as regards bulk, weight and density, and surrounded with an atmosphere higher than ours. We know that it gravitates like our floating island in the light and heat of the sun, and that its brilliancy has no other cause than this reflected light. We know, too, that our earth exhibits the same luster from a distance, and we have even some right to think that the inhabitants of Mars have given our planet all the qualities that we have given to Venus. We are also for them the morning and evening star—the star of confidences and mystery, and they have doubtless erected altars to us. There is one communication like another between the worlds while awaiting the true one. Is not light a celestial bridge thrown between the worlds in space? Through it they see each other, feel each other, and know each other, and space, instead of being a separation, becomes a bond between all.

The analysis of this light permits us to determine the chemical constitution of these inaccessible stars, which at the same time communicate with each other through that universal law of gravitation by virtue of which the planets of the heavens mutually attract each other through the extent thereof, and act upon each other constantly and reciprocally.

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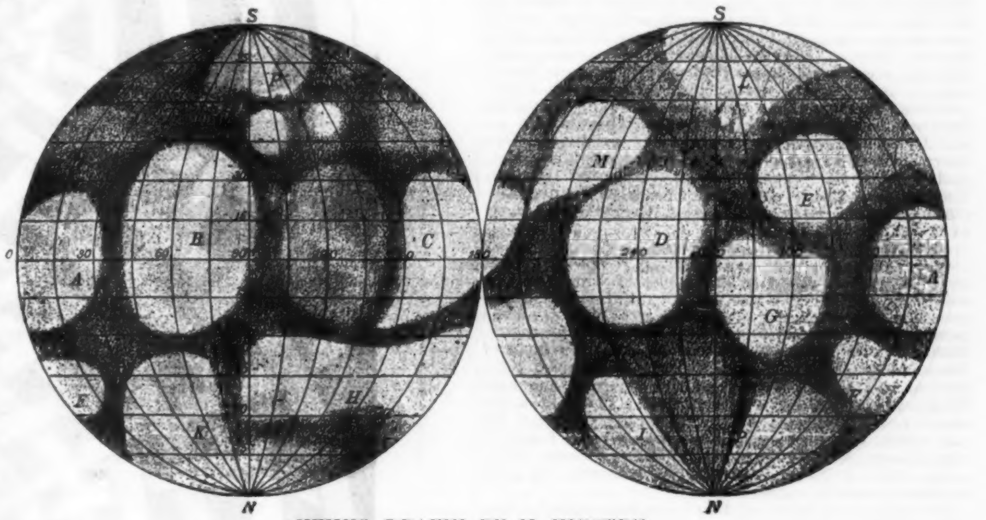
Of all the planets of our system, Venus is assuredly the one which most resembles the earth; and we have some apparent reason for thinking that its inhabitants may offer an organic analogy with us completer than those of Mars, our other neighbor, and than those of Jupiter or Saturn, whatever be the epochs of their existence, seeing that the worlds are of different ages and cannot have been inhabited at the same time. Venus, in fact, has sensibly the same diameter as the earth. Instead of measuring 12,742 kilometers in diameter, Venus measures 12,729. The difference is insignificant. The area of Venus is scarcely less than that of our globe, and the same is the case with its bulk.



VENUS, DRAWN BY M. NIESTEN.

Our knowledge of its geography is much less advanced than that of the planet Mars, yet it is begun and several representations of it have already been attempted. The best and surest is the map that has just been made by Mr. Niesten, astronomer of the Brussels Observatory, and that we are happy to put before the eyes of our readers. The light spots A, B, C, D, etc., probably represent continents, and the dark ones seas.

This map is as yet merely provisional, but [illegible] a observation of Venus is so difficult, the planet [illegible] constantly covered with clouds, that it will be a l[illegible] time before we shall have a more certain one.

The temperature may be higher thereon than it is in our tropical regions, if the atmosphere is not unfavorable to it. For there is here a condition that is too often forgotten, and that is that the physical and chemical constitution of the atmosphere plays a greater role than the distance from the sun in the production and distribution of temperatures. A rarefied and dry atmosphere composed solely of oxygen and nitrogen deprived of aqueous vapor would be incapable, at the surface of the globe, of preserving the heat received from the sun. Such heat would be constantly lost in space, and we should have upon the entire earth the climate of the alpine summit crowned with eternal snows. The summits of the Jungfrau are at the same distance from the sun as the lakes and valleys of Switzerland, and yet the climate of the first is uninhabitable, while that of these enchanting landscapes is as fertile as it is delicious. It is the density of the atmosphere, and it is especially the aqueous vapor distributed in the air, that exerts the most advantageous influence. One molecule of atmospheric vapor is 16,000 times more efficacious than one molecule of dry air for storing up the solar heat. An atmosphere thus constituted acts like a hothouse—it allows the solar heat to enter, and does not allow it to make its exit.

Upon Venus, as upon the earth, it is therefore the constitution of the atmosphere that regulates the temperatures. Have we accurate data as to this atmosphere of Venus? Yes; and even *very* accurate data.

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She has revealed herself to the gaze of observers since the first studies made of her phases. The limb of her crescent or of her quadrature is not sharp or decided, but undulating and indefinite. This limb

represents for the terrestrial observer the countries upon which the sun rises or sets. It is the line of the aurora and twilight. It is an evident proof of the existence of an atmosphere. It is seen at the first glance every day at this moment, and I have just again observed it.

Through spectrum analysis, we know that this atmosphere much resembles our own in its chemical composition. We recognize therein the rays of absorption of aqueous vapor, but in feeble quantity, as if the solar light reflected by Venus had not traversed a thick atmosphere, but was sent back by the upper surface of a stratum of clouds. The fact is so much the more probable in that there is constantly here an extraordinary whiteness.

The atmosphere of Venus is almost twice denser than ours. What is the action of this atmosphere upon the climates of Venus?

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On the one hand, being denser and higher, and, moreover, quite rich in aqueous vapor, it must act like the hothouse mentioned above, and store up a large part of the incident solar heat. But here another factor intervenes. The effect of this heat is to evaporate the water of the seas, and the vapor produced, reaching the cold heights of the atmosphere, is condensed into clouds. The whiteness of Venus, the impossibility that all observers have experienced of distinguishing the geographic configurations of its surface with any precision, concur to confirm this view, and to convince us that an immense stratum of clouds extends constantly in these aerial heights.

This stratum of permanent clouds must render climates temperate which would otherwise appear torrid.

But here we are estopped in our description of the world of Venus through the ignorance in which we stand concerning its oceans and the distribution of its land. Geographical configuration exerts a great influence over climates. If the Atlantic Ocean did not exist, Paris would have the climate of Cracow. And then there is another problem, and it is this: What is the length of the day upon Venus?

The length of the year is known. It is 224 terrestrial days. But the duration of the revolution, which it was thought only a few years ago was fixed at 23 hours, 21 minutes, and 22 seconds, has been put in doubt by the observations of Mr. Schiaparelli, according to which the planet constantly presents the same hemisphere to the sun. There would thus be an eternal day on one side and an eternal night on the other. On one hemisphere, light, heat, electricity, and all their consequences, and, on the other hemisphere, nocturnal darkness, cold, lethargy, and death. There would assuredly be here strange conditions of existence. But there is not as yet anything certain upon this point, and even the last observations presented by Mr. Trouvelot to the Astronomical Society of France conclude on a rotary motion analogous to that of the earth of about 24 hours.

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One unexplained phenomenon is perhaps connected with the long exposure of the globe of Venus to the solar light, and that is the visibility of its non-illuminated disk in the interior of the crescent. Every one has been able to remark, at the epoch of the new moon, during the first days of the crescent, that the body of the moon not lighted by the sun is visible in the interior of the crescent, pale, grayish, scarcely marked. This is what is called the ashen light. The part of the moon non-illuminated by the sun is then lighted by the earth, which reflects into space a light fourteen times more intense than that of the full moon. This ashen light of the moon is thus the reflection of a reflection, perfectly explained.

But no known cause explains the same aspect often observed upon Venus. Could it be a fluorescence or a *phosphorescence* of its clouds or its seas?

The astronomer Gruithuisen dared to attribute this brightness to illuminations made by the inhabitants of Venus, on days of political and religious fetes.

Fontenelle somewhere speaks of a world deprived of moon, and in which the rocks composed of phosphorus store up the solar light and send it forth during the night in thousands of varied hues. I believe even that he adds thereto glow worms and moths flying like sparks of fire in the warm and almost hot atmosphere (I do not dare say electrified, for the ingenious author knew nothing about electricity). Bernardin de Saint-Pierre represents to us the landscapes of Venus ornamented with tropical plants bearing magnificent fruit and inhabited by humming birds of brilliant plumage, turtle doves, and lovers. Tranquil lakes reflect the azure of the sky, and beings ravishing in form and agility dispute with each other there, in swimming, for prizes that Pleasure will crown.

We cannot yet affirm that the abode of Venus is absolutely delicious, that there do not exist there summers too hot nor winters too cold, nor physical or moral miseries, nor even perfidies great or small, masculine or feminine. But we may think that nature has been able to provide this habitation, whatever it be, with organized beings for accomplishing their destiny thereon, and it is perhaps not difficult to imagine that these unknown brothers are a little more intelligent—a little more *intellectual* especially—than their neighbors of the earth. They ought not to resemble us. We have an innate tendency to seek in the unknown life for a resemblance, an analogy with ours. We are vaguely penetrated with the idea that the planetary humanities must have been formed upon the type of our species, and it seems to us that no beings can have existed without having been organized in our image. We would not only have them breathe as we do, eat and drink after our manner, and act, walk or sleep, but we also pretend to figure them in the same form and do not conceive of beings which may be neither men nor women, or may not have legs, lungs or stomach, or which, instead of five senses, may have ten or fifteen, among which ours may not be included. Still, as the human form is the result of the organic forces in activity on the surface of our planet, there is no reason that the inhabitants of the other worlds should resemble ours.

We have no plausible reason for imagining that the inhabitants of the other worlds of space are made in our image either as to form or organic substance. The substance of the terrestrial human body is due to the elements of our planet, notably to carbon. The terrestrial human form is derived from ancestral animal forms from which it has gradually risen through the continued transformation of beings. It doubtless appears well to us that in order to be a man or woman, it is necessary to have a head, a heart, lungs, two legs, two arms, etc. We are constituted as we are solely because the prosimians had also a head, a heart, lungs, legs and arms, less elegant than yours, madam, undoubtedly, but of the same anatomy. By degrees, we easily ascend to-day, through paleontology, to the origin of beings. It is just as certain that the bird is derived from the reptile by a progress of organic evolution as it is that the human kind of the earth represents the summit of the immense geological tree of which all the branches are brothers and whose roots penetrate the very rudiments of the most elementary primitive organisms.

All the forms imaginable and unimaginable must people the multitude of the worlds. The terrestrial man is endowed with five senses, or more properly six. Why should nature have stopped here? Why, for example, should it not have endowed certain beings with an electric sense, with a magnetic sense, with a directing sense, with an organ perceiving the ethereal vibrations of the infra-red or of the ultra-violet, permitting of hearing at a distance, or of seeing through walls? We eat and we digest like coarse animals. Do not worlds exist in which the nutritive atmosphere allows the inhabitants to dispense with so ridiculous a labor? The smallest sparrow and the somber bat have the advantage over us of flying in the air. Is not ours a very inferior world, where a man of the greatest genius or the most exquisite woman find themselves tied down to the earth like vulgar caterpillars before metamorphosis? Would it be so disagreeable to inhabit a world in which we might enjoy the privilege of flying whither we chose; a world of perfumes and pleasures where the flowers are animate; a world upon which the winds are incapable of fomenting a tempest; where several suns of different colors (the diamond associated with the ruby or the garnet with the emerald and the sapphire) radiate night and day, blue at night and scarlet by day, in the glory of an eternal spring, many-colored moons slumbering over the mirror of the waters, phosphorescent mountains, aerial inhabitants, men and women or perhaps other sexes perfect in their form, as incombustible as asbestos, endowed with a multiple sensibility, luminous at will, perhaps immortal? Liliputian atoms that we are, let us then once for all be well convinced that all our imagination is only a barrenness in the midst of the infinite, scarcely caught sight of by the telescope. And on these beautiful spring evenings while Venus is shining with all her brilliancy, in face of the sublime spectacle of the starry night, when we think of the unknown worlds that fill space, let us be assured that they are inhabited, have been or will be, their vital cycle not being necessarily contemporaneous with ours, and that an infinite diversity reigns in the fields of the heavens as in the gardens of the earth. There are there humanities, a great number of which must be incomparably more advanced than ours upon the route of perfection.

Our earth, with all its political, social and religious history, is only a poor and small ant hill, is only the flight of a dragon-fly of one day in a ray of the sun.—*Camille Flammarion in L'Illustration.*

KELTIC DESIGNS.

By A. SAVIL.

THE designs here shown are taken from "The Book of Kells," only enlarged about a hundred times, and also slightly modified, as the original forms part of a very elaborate border.

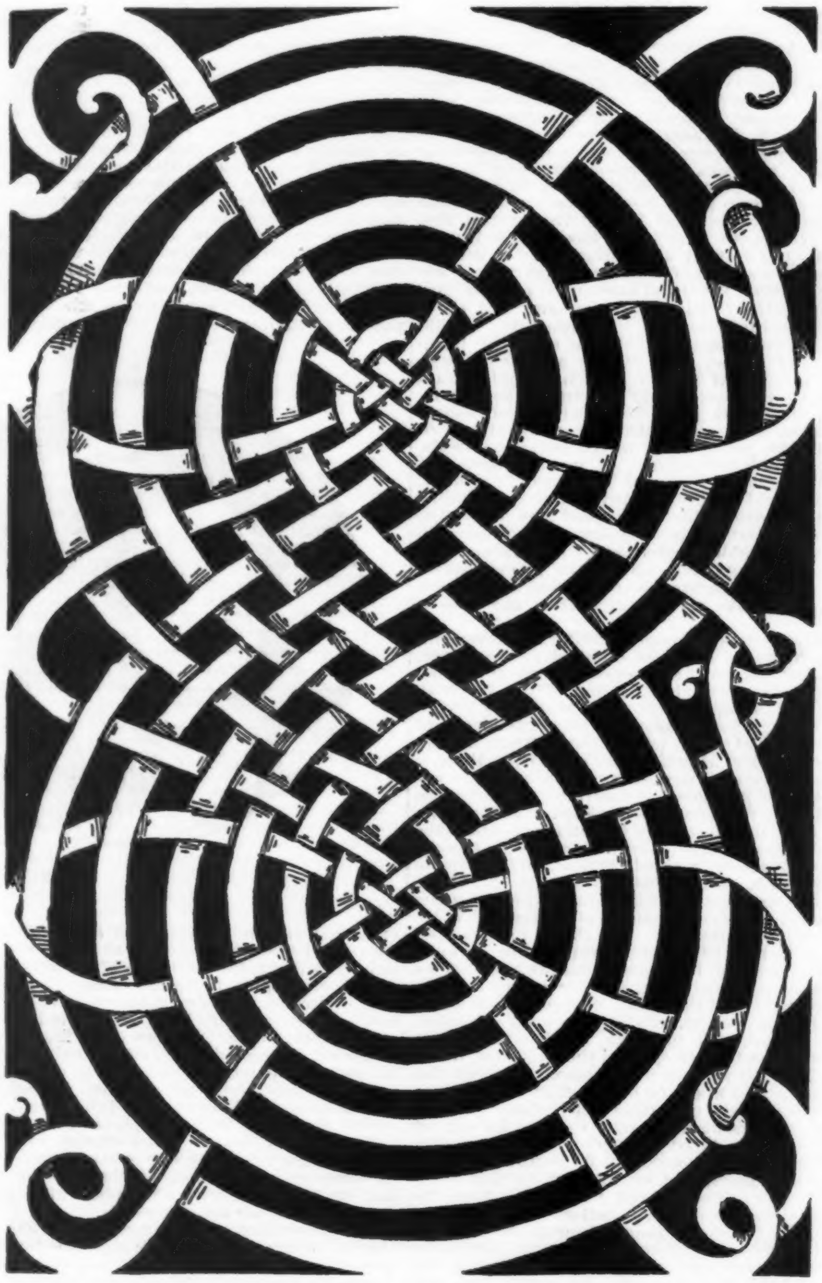

FIG. 1.—DESIGN SUGGESTED FROM DESIGN IN THE BOOK OF KELLS. ENLARGED 100 TIMES.

The other example is also greatly enlarged, and is taken from a small design in gold ribbon work adorning an article of no less antiquarian interest than the shrine of St. Patrick's Bell. Perhaps no relic of a long past age possesses so unbroken a history as this shrine; and, in offering this panel to the readers of the *Journal of Decorative Art*, I may claim that there is authentic evidence that the subject from which it is taken was made by Irish workmen before the year 1103, or nearly eight centuries ago

The design is suggestive for use in many purposes—if not in its present state, then in a modified form. The great charm which attaches to much of the Keltic work, as it does to many of the geometrical shapes of Greek work, is the admirable balance maintained between ground and pattern.

This, probably, is more obvious in the elaborated and more intricate design. (Fig. 1.) The points to be noticed in it are two—first, the nice proportions observed between ground and pattern; and, second, the gradual and delicate fining down of the strength of the lines as they approach the two centers. In the best of the old Runic crosses these are points always to be found, and it is this which, insensibly, but very neatly, adds so much to their beauty. Many

devices of great decorative quality may be wrought by working upon these lines.—*Jour. Decorative Art.*

WHEN SHALL WE HAVE ANOTHER GLACIAL EPOCH?

By GARRETT P. SERVISS.

THE enunciation by Sir Robert Ball of the fact, which seems to have been first clearly brought to light by him, that of the total amount of heat falling from the sun in a year, upon either the northern or the southern hemisphere, 63 per cent. is received in summer and 37 per cent. in winter, has awakened renewed interest in the problem of the glacial epochs. Dr. Ball's theorem not only strengthens the astronomical explanation of the cause of such epochs, but also adds to its clearness. This explanation may be summed up in a few words.

It must be remarked, to begin with, that the summer and winter here spoken of divide the whole year between them, the equinoctial points marking the lines of division, spring and autumn being merged into the greater seasons. Everybody knows that summer in the northern hemisphere, counting summer as extending in the broader sense just mentioned from the vernal to the autumnal equinox, is about seven days longer than winter. In the southern hemisphere just the opposite condition prevails. This difference arises from the eccentricity of the earth's orbit. If the orbit were a circle instead of an ellipse, winter and summer would be of equal length.

But the elliptical orbit of the earth is not absolutely fixed, either in form or in its position in space. Owing to the varying attractions of the other planets, and more particularly of *Venus* and *Jupiter*, the earth's orbit is alternately rounded up almost into a circle, and then drawn out into a more eccentric ellipse. These changes require vast intervals of time, so that we must go far back into the geological ages in order to obtain evidence of their effects upon the earth. But it is clear, theoretically, that great seasonal vicissitudes must result from such variations in the form of the earth's orbit. When it approaches nearly to a circle, which is its condition now, the difference in the length of summer and winter is small; when it is in its state of greatest eccentricity, the difference is large, amounting under the most favorable circumstances to as much as thirty-three days, or some authorities say even more, instead of seven days, its present amount.

Now the theory in question asserts that the glacial epochs in the history of the earth have occurred during those periods when, the eccentricity of the orbit being large, the difference in the length of summer and winter was at or near a maximum. Such a maximum will, of course, occur whenever the line of equinoxes is perpendicular to the major axis of the orbit. Under such circumstances one hemisphere would have 199 days of winter and 166 days of summer, while the other hemisphere had 166 winter and 199 summer days. But there would be no difference in the distribution of the heat coming from the sun. Just 63 per cent. of it would continue to be received in summer and 37 per cent. in winter in each hemisphere. The hemisphere which had 199 days of winter would have to spread the 37 per cent. of heat belonging to that season over all those 199 days, while the 63 per cent. of summer heat would be concentrated upon the shorter period of 166 days. Accordingly there would be a very long and cold winter, followed by a short and hot summer. The heat of the latter would not suffice to melt away the snow and ice accumulated during the former, and this accumulation would go on until whole continents were buried under a blanket of ice thousands of feet thick. In the other hemisphere there would be, on the contrary, a short, mild winter and a long summer. So glaciation in one hemisphere would be accompanied by genial climatic conditions in the other.

Such is, in brief, the outline of the astronomical theory of the cause of glacial epochs. I have purposely used the plural in describing such epochs, although we commonly hear only one ice age spoken of, because one of the most interesting points about this theory is that while accounting for that age of ice whose handiwork is so familiar to geologists in the northern hemisphere, it also demonstrates that there must have been many glacial epochs of varying intensity in the past, and that there will be many more in the future.

This wonderful thing, the burying of half of North America and the greater part of Europe under ice, and the absolute destruction of all their manifold forms of life, can then happen again, nay, must happen again. Naturally, the question arises, when? A precise answer cannot be given, owing to the intricate nature of the causes at work, but it seems possible to give an approximate answer. Dr. James Croll, in his work on "Climate and Time," has computed the periods of greatest and least eccentricity of the earth's orbit for a million years to come and for a still greater period of time in the past. About 853,000 years ago the eccentricity attained its greatest possible amount. From 240,000 down to 80,000 years ago the orbit continued to be very eccentric, and Dr. Croll's conclusion was that the latest ice age in the northern hemisphere ended with the close of the period of high eccentricity 80,000 years ago.

In the future, according to Dr. Croll's tables, the earth's orbit will become highly eccentric about 150,000 years from the present epoch. Until that time, it appears, we shall be reasonably secure from any invasion of the ice. But the eccentricity then to be attained will be by no means the greatest possible. It will amount, according to Dr. Croll, to 0·0353, as against 0·0168 at present, so that if even a glacial epoch then occurs it will probably not be so severe as some of those that have occurred in past time, or some that may be expected in the future. But there are three future periods of very great eccentricity indicated by Dr. Croll, which will attain their maxima in 800,000, 900,000, and 1,000,000 years respectively from the present time, and when glaciation in its severest form may occur in one hemisphere or the other, or more probably in both alternately. Dr. Croll's estimates of the eccentricity of the earth's orbit at the three dates just mentioned are 0·0639, 0·0659, and 0·0528.

It is interesting to note that during the periods of minimum eccentricity to which Dr. Croll calls attention as separating these three periods of high eccentricity, the orbit will be even less eccentric than it is at the present. The minima will occur in 850,000 years, with the eccentricity at 0·0144, and in 950,000 years, with the eccentricity at 0·0086. But, both the descent from the high eccentricity of 800,000 years hence to the minimum in 850,000, and the subsequent ascent to the maximum in 900,000, are very sharp and steep, and the same is true of the next following minimum and maximum in 950,000 and 1,000,000. In view of these facts one is tempted to speculate as to the chances of recovery that the animal and vegetable forms of the regions afflicted by glaciation during these coming periods of high eccentricity would have in the comparatively few thousand years of respite from the ice that would intervene between the maxima.

It will be observed that while ice ages are unquestionably recurrent phenomena, yet they are not separated by anything like regular intervals of time, simply because the conditions favoring their production do not recur at regular intervals, but are the results of exceedingly complex influences. Moreover, ice ages come in pairs or sets, alternating between the northern and southern hemispheres. This fact arises from the precession of the equinoxes, by which, once in every 10,500 years, an interchange of condition is effected between the hemispheres. At present, for instance, we in the northern hemisphere have our winter when the earth is nearest to the sun, and it is seven days shorter than the summer. In the southern hemisphere, on the other hand, winter occurs when the earth is furthest from the sun, and is seven days longer than the summer. If the eccentricity of the earth's orbit were as great now as it will be 150,000 years from now, and more particularly as it will be 800,000 years hence, the southern hemisphere at present would be suffering from a glacial epoch while we should enjoy short, mild winters and equable summers, longer than those we have now, but not quite so hot. In about 10,500 years, however, a comple interchange will have taken place, and then our hemisphere will have its winters when the earth is furthest from the sun, and its summers when it is nearest. It will hardly be so comfortable in the United States and Europe then as it is in our day, although no glacial invasion is to be expected.

It is because the periods during which the earth's orbit remains greatly eccentric, when once drawn out by planetary attraction, are far longer than 10,500 years, that two or more successive ice ages may occur in each hemisphere during the prevalence of a single period of high eccentricity. If the condition of great eccentricity were a phenomenon of comparatively brief duration, both hemispheres might escape glaciation during such a period, because it might happen that, while the orbit was drawn out into its extreme state of eccentricity, the equinoxes would nearly coincide with the apsides, and so winter and summer would be of equal duration.

As long as no outside influence interferes with the regular procession of the planets, and the astronomer cannot foresee although he may admit the possibility of such interference, we may count upon our globe remaining a genial abode, neither too hot nor too cold, though subjected to some vicissitudes of climate; and long before the next period of high eccentricity has blasted our fair continent with the chilling breath of the glaciers, the race of man may have had its day.—*Astronomical Society of the Pacific.*

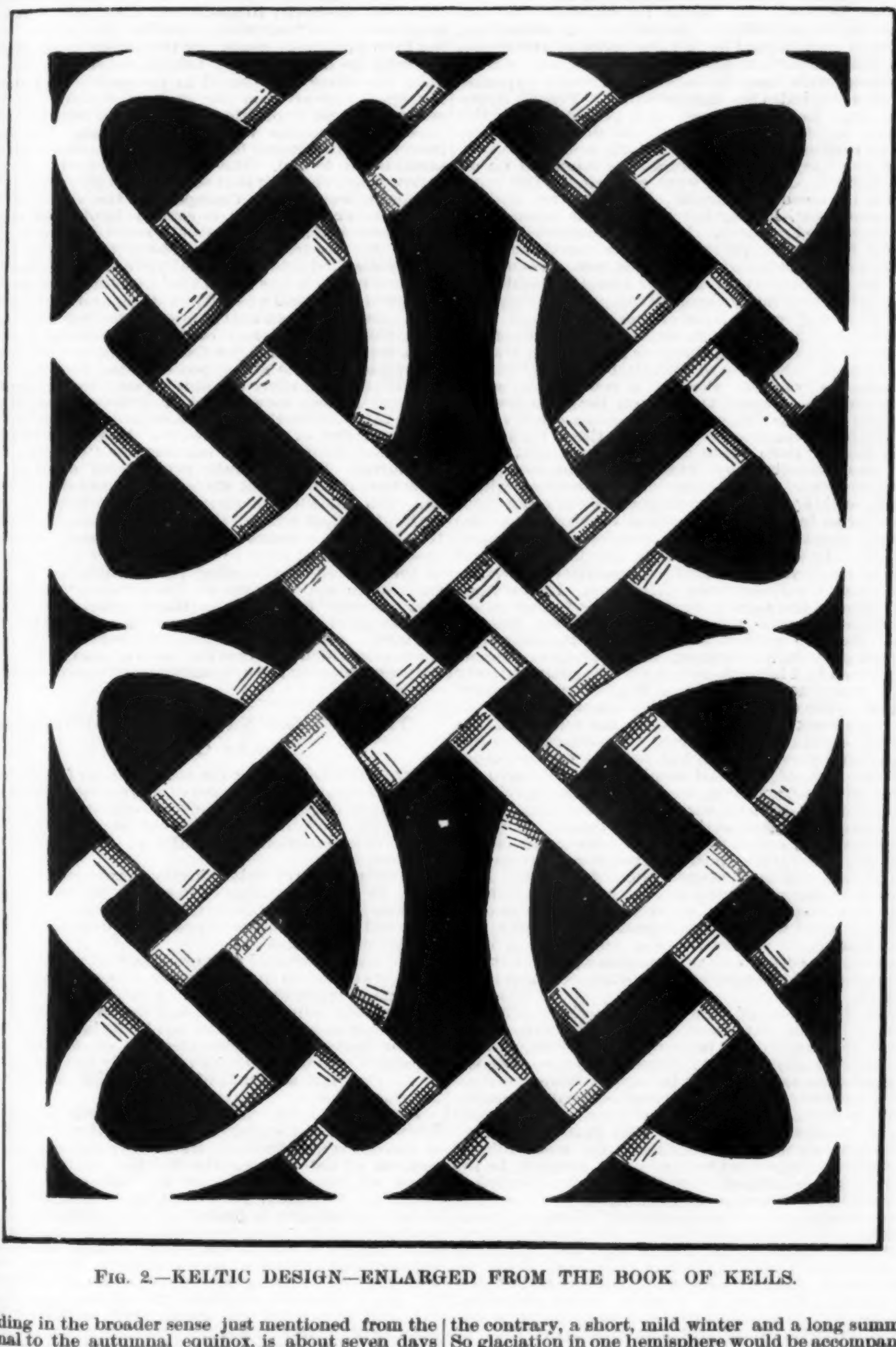

FIG. 2.—KELTIC DESIGN—ENLARGED FROM THE BOOK OF KELLS.

DR. D. HAYES AGNEW.

MINUTE on the death of Dr. D. Hayes Agnew, adopted by the College of Physicians of Philadelphia, March 24, 1892: "The death of Dr. D. Hayes Agnew, recently president of the college, in the seventy-fourth year of his age, and after a life crowned with honor and usefulness, calls for an expression of the sense entertained by the college of the gravity of the loss which it suffers, in common with the profession he adorned, the charitable institutions he served, and the community in which his skill did so much to lessen suffering and death. He began his professional life with no adventitious aids; yet by incessant industry, indomitable perseverance, and singleness of purpose he attained to its highest rank. No temptation distracted his attention from the goal of his life—neither extraneous science, nor general literature, nor the allurements of art, nor the pleasures of society. The undivided strength of his mind and his affections were devoted to enlarging the domain of surgery, not only in its operative methods—which he always subordinated to the welfare of his patients—but also in preparing for his profession a literary monument that might speak for him when his voice should be no longer heard. His minute acquaintance with anatomy and his ambidextrous skill enabled him to perform with ease to himself and safety to his patients operations which less accomplished surgeons hesitated to undertake. He possessed a certain magnetism of manner, quite independent of formality, that evidently pro-

ceeded from the heart, and drew all hearts to himself. Never frivolous, but always cheerful, he was dignified, grave and earnest, making all who heard him as a teacher and speaker, or in familiar intercourse, recognize in him, above all other things, the upright man. For he possessed eloquence of conviction, and the force of absolute honesty in all his statements, and thereby drew to himself, as enthusiastic admirers and disciples, the successive classes of students whom he taught. The college, desiring to show respect for the purity, uprightness, unselfishness, and modesty of Dr. Agnew's character; its admiration for the noble example of his life; and its sense of the value of his contributions to the science and art of surgery, directs that this minute shall be duly recorded, and a copy of it, signed by the president and secretary, be conveyed to Dr. Agnew's family. Also, that the college will attend the funeral in a body, and that the president be requested to appoint a fellow to prepare a memoir of our late colleague."

The late Dr. D. Hayes Agnew, says the *Post-Graduate*, "was for many years a great teacher in Philadelphia, at first in a school of anatomy not directly connected with either of the colleges. At a comparatively late time in life he became Professor of Clinical Surgery in the University of Pennsylvania, but he had achieved his fame before then in a private institution, a school of medicine something like the *extramural* schools in Edinburgh. He will always be remembered as associated with our Frank Hamilton, in President Garfield's case. It is generally supposed now that the great uncertainty that existed, until death occurred, as to the track and final lodgment of the ball, would have been much less had the President been first seen by such surgeons as those who finally had the actual surgical responsibility. When Hamilton and Agnew were called, it was too late to make a thorough examination, without great risks. The final result, however, would have been the same, in any case, for the original lesion was necessarily fatal. Dr. Agnew—like his namesake, the great oculist of New York, Cornelius Agnew, who was in no way related to him—was a man of profound religious character, who had a great influence for good in even a larger circle than his professional life circumscribed. A really great man has fallen in our front ranks. Very few physicians, however eminent, leave an estate of a quarter of a million of dollars, as Dr. Agnew has done. He left fifty thousand dollars to the hospital of the University of Pennsylvania."

THE CHEMICAL RESEARCHES OF JEAN SERVAIS STAS.

By VAUGHAN CORNISH, B.Sc., F.C.S.

IN the last month of last year the chemical world received with profound regret the news of M. Stas's death, at the advanced age of seventy-eight.

The name of Stas has been a household word among chemists for half a century, and his writings, the celebrated *Recherches sur les Lois des Proportions Chimiques*, have come to be regarded as among the canonical books of chemistry. In all that related to the experimental art Stas stood unsurpassed. The marvelous patience with which he matured his methods, and the skillful care with which the final experiments were carried out, stand recorded in his classical memoirs with that clearness and precision of expression characteristic of French scientific writings. Stas's work bore on one subject only, the determination of "atomic weights," with a view more particularly to ascertain if there existed any simple definite relation between the weights of the chemical atoms. In order to explain how this investigation came to be the mission of Stas's life, we must refer to the state of chemical theory in the second decade of the present century. At this time the laws of chemical combination had been formulated and accepted—the laws, viz., which may be epitomized by saying that "chemical elements combine together only in the proportion of their equivalent weights, or in simple multiples of those proportions." Dalton had propounded an explanation of these laws in his "Atomic Theory," according to which chemical combination was due to the union of chemically indivisible particles, the particle or atom of each element having its own particular fixed weight.

Dalton's theory, the next great generalization after Lavoisier's explanation of the phenomena of combustion, was the result of the discovery of definite and simple numerical relations between certain chemical quantities. It was natural that other minds, impressed by Dalton's theory, should seek for other such numerical relations in the hope of fresh discoveries of Nature's laws. In 1815 a paper appeared in Thomson's *Annals of Philosophy* by Dr. Prout, in which he pointed out certain apparent relations between the atomic weights of the elements as then determined. The idea was at once taken up by other chemists, and took shape in the following form, known as *Prout's Hypothesis*: "The weight of the atom of each element is a simple multiple of the weight of the atom of hydrogen." The observed deviations were referred to errors of experiment, just as the apparent deviations from the laws of chemical combination were referred to experimental error.

It has been the life work of Stas to investigate both assumptions, and to show that while the laws of chemical combination are rigidly exact, the supposition of Prout is unsupported by experimental evidence.

Prout's hypothesis owes its importance in the history of science to the fact that it seemed to restore the old theory of the unity of matter, which appeared to have received its death blow with the discovery of the chemical *elements*. But if the atom of each element be exactly once, twice or thrice the weight of the atom of hydrogen, then it is reasonable to suppose that the atoms of all elements contain only one kind of matter, and that the hydrogen atoms are the one class of ultimate particles of which all matter is built up. As the art of chemical analysis developed under the hands of the great Swedish chemist, Berzelius, it became evident that Prout's hypothesis was not tenable in its original form. It was revived, however, in a modified shape chiefly owing to the influence of Dumas. In the modified form, the hypothetical unit weight was that of the half atom of hydrogen. Later on, Dumas was compelled to retreat yet further from the original position, and to take the quarter atom of hydrogen as the greatest common divisor of the atomic weights. In this modified form the idea of Prout loses much of its interest, since the "quarter atom" of hydrogen is itself an unknown thing. Nevertheless, the idea of the oneness of matter always exerts a certain fascination, and to some minds this unity of matter appears to be almost a logical necessity. Hence the tenacity with which chemists have clung to the belief that apparent discrepancies were due to errors of experiment, rather than to the inaccuracy of Prout's hypothesis.

Stas began his researches on atomic weights with a strong prepossession in favor of the hypothesis. He chose for his determinations such substances as could be prepared in a high state of chemical purity, and worked with large quantities of substance in order to eliminate the effect of errors in weighing. A large number of experiments, which occupied several years, furnished him with extremely accurate values for the relative weights of the atoms of silver and the alkali metals, and of chlorine, bromine, and iodine. Moreover, the variety of methods employed served to eliminate possible systematic errors—errors, that is to say, not due to want of skill in the performing of an experiment, but due to the method itself. Each substance, moreover, was prepared in several different ways and from different natural sources. Not the least remarkable tribute to Stas's skill is the close accordance between the values he obtained for the atomic weights by different processes of determination. The numbers obtained in this first series of researches were closely accordant among themselves, and wholly at variance with those demanded by Prout's hypothesis. Stas concludes his memoir thus: "Prout's hypothesis must be looked upon as a pure delusion; the elements must be considered to be distinct entities, with no relation between their atomic weights."

The accuracy of Stas's work was admitted on all sides, but his conclusions were contested. The criticisms of the Genevese chemist, Marignac, are historically important, having led Stas to his second and more celebrated research. Marignac contended that it was far from being proved that the constituent elements of many chemical compounds were present exactly in the proportion of their atomic weights. It was possible that many chemical compounds contained normally a very small excess of one or other of their constituents. This criticism strikes at the basis of the atomic theory, since that theory is founded on the assumption that the laws of chemical combination are mathematically exact. For half a century the scientific world had accepted the dictum that the laws of chemical combination were *lois mathématiques*, but the original experiments on which these laws were based were far from being models of accuracy. This fact was admitted by Stas, who undertook the laborious task of a re-examination of those laws, with a view to settle by the most exact methods whether these laws were in fact of mathematical exactness, or, like so many physical laws, only *lois limites* or approximate relations. In 1865, five years after the date of his first series of researches, appeared the *Nouvelles Recherches sur les Lois des Proportions Chimiques*. In this work Stas repeated the more important of his former determinations of atomic weights, with additional precautions. He also subjected to the most rigorous tests the laws of definite, constant, and equivalent proportions which had hitherto rested on the comparatively rough experiments of Dalton, Wollaston, and other workers of the early part of the present century. In this great work Stas confirmed, on the one hand, his previous conclusion that Prout's hypothesis was unsupported by experiment, but showed on the other that the laws of chemical combination, hitherto accepted on insufficent data, were, as far as experiment could prove, actual and veritable mathematical laws. It is impossible to overestimate the benefit conferred upon science by a man who has the courage to devote years of patient labor to the re-examination of points such as this, and the reinvestigation of supposed laws which have been accepted on the evidence of insufficent experimental data. Such work is much needed in the chemical world at the present time, when a vast superstructure of theory is being built upon a comparatively small number of approximate experiments with regard to the behavior of substances in a state of solution.

From the point of view of the working practical chemist the most important aspect of Stas's researches is that relating to the preparation of chemical substances in a state of purity. Since Stas's time chemists have not been satisfied with the approximate purification of substances which in general sufficed the earlier experimenters. The approximate isolation or purification of substances is the first step in a chemical research; the complete purification is the most difficult and the most important part of exact research in the science. Stas's methods of purification have served as a model for all subsequent experimenters. In order to give a general idea of the character of his work we will describe a method he adopted for the purification of silver, a substance which is, as he says, the "pivot" of his determinations. Silver is a substance which, as Stas showed, can be obtained in a state of almost perfect purity. The way in which it resists oxidation, and the distinctive character and insolubility of certain of its salts, would lead one to suppose that its complete purification would be very readily effected. That this not exactly the case will be evident from the following description of Stas's method. In order not to make the description unduly long, we omit the special methods of purifying the *reagents* used in the work. These reagents are water, nitric acid, hydrochloric acid, caustic potash, and milk sugar. Each of these had to be submitted to special processes of purification, lest their use should introduce foreign substances into the silver.

Coinage silver was taken, and dissolved in very dilute nitric acid. Any gold present is left undissolved. The solution of the nitrate is evaporated to dryness, and heated till no more nitrous fumes are evolved. The salt is then dissolved in a small quantity of water. On filtering, any platinum present is left behind. The filtrate is then diluted with about thirty times its volume of water and an excess of hydrochloric acid added. All the silver is then precipitated or thrown down in the form of the insoluble chloride of silver. Any copper and iron present remain in solution. The liquid is poured off and the precipitate washed, first with dilute hydrochloric acid and then with water, till the washing appears to be pure water containing no trace of copper or of hydrochloric acid. This washing of a large quantity of a precipitate is a very lengthy and tedious operation, requiring days or weeks, according to the quantity of the precipitate. The washing is effected in this case by shaking up the precipitate with water in a stoppered flask, allowing the precipitate to settle, and pouring off the liquid. All the operations with chloride of silver were carried out in a room lighted by artificial light, since daylight, as is well known, effects a chemical change in the composition of chloride of silver. The chloride of silver, purified as above, is brought on to a cloth (previously washed with hydrochloric acid) and the water squeezed out. After drying, the silver chloride is pounded fine in a mortar, and *reduced* to the metallic state by warming for forty-eight hours with a solution of caustic potash and milk sugar (both carefully purified). The finely divided metal is then fused, with special precautions to prevent access of impurities. By this process Stas hoped to obtain an ingot of perfectly pure silver, but found that, besides very slight traces of other substances, there remained an appreciable quantity, 2 parts in 100,000, of silica. Experience convinced Stas that no substance can be obtained absolutely pure except by distillation. He therefore subjected the silver obtained as above to the process of distillation from one cavity to another in a hollowed block of quicklime made from white marble. The cavity having been previously heated by the oxyhydrogen flame, in order to drive off any volatile substances such as soda, the silver was placed in the cavity and fused. No scum appeared on the surface, showing the absence of certain impurities such as iron, which under these circumstances would form a slag. The heat from the oxyhydrogen flame was then increased till the metal began to boil. The vapor had at first a strong yellow tinge, showing that sodium was still present.

This, however, soon disappeared, the vapor of the silver showing no color beyond a faint blue tinge. The absence of any green tint showed that the substance was free from copper. The metal having completely distilled into the second cavity, or receiver, in the lime block, it was found that absolutely no residue remained, the small quantity of silica, and any similar fixed substance of an acid character, having combined with the lime, and any oxidizable material having been burnt away by the flame of the oxyhydrogen blowpipe. By the above process Stas believed that he had obtained silver absolutely pure. Subsequently, however, Dumas showed that silver thus prepared absorbs, after distillation but while still molten, a certain quantity of oxygen which does not combine chemically with the silver but remains "occluded" in the metal. The elaborate precautions adopted by Stas were therefore not successful in obtaining even this well known and characteristic substance in a state of perfect purity, though he subsequently determined the amount of oxygen present. But the practical chemist owes to Stas a proper appreciation of the difficulties attending the purification of substances, an appreciation of the necessity for taking every means to overcome these difficulties, and a knowledge of methods for the carrying out of this class of work; methods elaborated by Stas thirty years since, and which yet form the basis of many of the recent researches on the determination of atomic weights. —*Knowledge*.

THE DETERMINATION OF FLUORINE.

By AD. CARNOT.

FLUORINE enters into the composition of many natural substances, but we have often restricted ourselves to establishing its presence by qualitative experiments on account of the difficulties presented by its exact determination, especially in the presence of silicates.

Many methods of determination have certainly been given by eminent analysts—Berzelius, H. Rose, Woehler, Fresenius; but in these methods accuracy has been obtained only by means of great complications or very minute precautions.

The method which I now propose, and which I have already applied to the analysis of a certain number of fluorine compounds capable of being attacked by concentrated sulphuric acid, has the advantage of being of easy execution, and of not being interfered with by the presence of carbonates or of organic substances; it can serve to show not merely the proportion of fluorine, but also that of silicon with satisfactory accuracy.

The process is founded, like several methods already known, on the disengagement of fluorine in the state of gaseous silicon fluoride; its novelty consists in the method of determining the volatile compound. In place of calculating it by the difference of two weighings (Woehler, Fresenius), or according to the weight of the calcium fluoride obtained after a tedious separation of the silica (Berzelius, H. Rose, and recently H. Lasne), I receive the silicon fluoride in a rather concentrated solution of pure potassium fluoride, with which it forms a precipitate of potassium silicofluoride, the weight of which enables us to calculate the fluorine, and if needful, the silicon, $SiF_2 + KF = KF.SiF_2$, or $F_4 + 2KF = K_2F_6$.

I indicate briefly the arrangement of the apparatus and the course of the operation.

The mixture of fluoride and silicate is acted upon by concentrated sulphuric acid in a small flask holding 150 c. c., to the bottom of which there is conveyed a slow current of air, or of carbonic acid, which has been perfectly dried by passing through bottles filled with sulphuric acid. The gaseous current is then conveyed by an elbow tube to the bottom of a flask containing a little mercury and above it 20 c. c. of a solution of pure potassium fluoride (1 part in 10). Beyond this there is an aspirator arranged so as to regulate the current.

The extremity of the tube which enters the flask should be drawn out to a point and bent back, opening 2 or 3 mm. below the surface of the mercury, so that it is not moistened by the aqueous solution.

The flask and the tube must have been perfectly dried either in the stove or after the apparatus has been connected by the action of the dry gas conjointly with that of heat, so as to avoid any decomposition of silicon fluoride by moisture. The elbow tube carries an empty bulb intended to retain the traces of sul-

phuric acid which may be carried along by the current of gas. There must be added a tube filled with pumice saturated with dehydrated copper sulphate to arrest the vapors of hydrochloric acid, when the fluoric substance contains also chlorides (apatite, etc.), for these vapors reacting upon the potassium fluoride might liberate hydrofluoric acid, which would attack the sides of the flask and the surface of the mercury.

The quantity of material taken for analysis should be such that the quantity of fluorine does not exceed about 0·100 grm.; we take therefore 0·200 grm. of rich fluorides (fluorspar, cryolite, etc.), and up to 2 grms. or upward of substances poor in fluorine (natural phosphates, bones, etc.) We mix the substance intimately in an agate mortar with ignited quartz in very fine powder, in such proportions that there may be at least 10 parts of silica to one part of fluorine. The quantity of silica must be still greater if the matter under examination contains less than 5 or 6 per cent. of fluorine.

When the apparatus has been fitted up, tested by means of the aspirator, and well dried, the current of gas is stopped for a few moments, we introduce into the flask the mixture to be attacked, and pour in 40 c. c. of pure concentrated sulphuric acid; then the current of gas is allowed to resume and the flask is heated upon a plate of iron, under which a gas burner is lighted. At the same distance from the burner we place a similar flask also containing 40 c. c. of sulphuric acid, into which plunges a thermometer which indicates in a sufficiently approximate manner the temperature at which the action takes place (Fresenius); we regulate the burner so as to reach a temperature close upon 160°, which must never be exceeded.

The small flask is shaken from time to time so as to liberate the bubbles of gas which form in the liquid or against the sides; they generally cease to be formed after 1½ or 2 hours, and we may soon after consider the attack as completed.

The potassium fluoride contains then a gelatinous precipitate of silicofluoride which is scarcely visible, and which would soon settle if the liquid were left in repose; but without waiting for this, we detach the tubes which lead to the flask, decant the aqueous solution, wash the mercury and the flask with several successive portions of water, and collect the liquids, the total volume of which should not exceed 100 c. c.; we add an equal volume of alcohol of the strength of 90 per cent., we mix the whole, and allow it to deposit.

When the precipitate is properly collected together, after having decanted off the supernatant liquid and replaced it with dilute alcohol, we collect the deposit upon a tared filter, and finish the washing with alcohol diluted with its own volume of water, making use of the filter pump until the liquid no longer occasions any turbidity in a solution of barium chloride. We dry at 100° until the weight is constant, and calculate the fluorine of the silicon fluoride. For $1KF,SiF_2$ we have $F_2 = 0·3451/$.

For the accuracy of the determination it is essential that the reagents employed should be free from fluorine. This is certainly the case with sulphuric acid if it has been heated to close upon its boiling point. It is the same with ignited quartz. However, both may be tested once for all in a blank experiment. The potassium fluoride should be free from silicofluoride; it is necessary to ascertain this point by dissolving 2 grms. of the salt in 100 c. c. of water, and adding an equal volume of alcohol at 90 per cent. No deposit should be produced, even if the liquid is allowed to remain at rest for 24 hours.

In the analysis of a fluoric silicate one and the same operation may serve for the determination of the fluorine and of the silicon, provided that the sides of the flask are not sensibly attacked. This result is obtained either when we operate upon a silicate poor in fluorine or if we mix very intimately by trituration in an agate mortar the fluoric substance with a great excess of quartz finely levigated and of pure silica, which is ignited and weighed exactly. The silicon is then calculated in two portions. A small portion is found along with the fluorine in the precipitate of silicofluoride. For $1KF,SiF_2$ we have $Si = 0·12714$; $SiO_2 = 0·28154$.

The other portion is found in the state of silica in the residue of the action of sulphuric acid, and may be separated and determined by the ordinary methods. The weight of the silica added must of course be deducted from the weight obtained.—*Comptes Rendus*, cxiv., p. 750; *Chem. News.*

PHOSPHATES OF POTASH AND AMMONIUM AS FERTILIZERS.

By Dr. T. MEYER.

THESE two commercial products, still but little known, do not consist entirely of potassium and ammonium phosphates, but contain a small quantity of sulphuric acid, which is also found in most mineral fertilizers. I started the preparation of the former five years ago and it is now made on the large scale.

The phosphates of potassium and ammonium are, according to their composition, simple products formed by the action of phosphoric acid on the corresponding sulphates, and their mode of preparation may be represented by the following equation:

$$K_2SO_4 + H_3PO_4 = KHSO_4 + KH_2PO_4.$$

It may be mentioned here that this reaction does not take place between sodium sulphate and phosphoric acid, at all events under ordinary circumstances. Experiments made upon this point have always yielded an oily deliquescent mass, simply a mixture of sulphate with phosphoric acid.

These salts contain 25 per cent. of phosphoric acid and 25 per cent. and 10 per cent. respectively of potassium and nitrogen. In addition to water, combined or otherwise, about 30 per cent of sulphuric acid is present, as well as a few per cent. of ordinary impurities, lime, oxide of iron, alumina, magnesia, hydrofluoric acid, etc. They only contain traces of chlorine, and the potassium and ammonia are not combined entirely with the phosphoric but also in part with the sulphuric acid. It is nevertheless apparent that the quantity of sulphuric acid introduced to no useful purpose into the soil is much greater in the case of superphosphate of ammonia than of sulphophosphate of ammonia. The former of these is a mixture of ammonium sulphate, calcium phosphate, and gypsum, while the latter may be considered as a mixture of ammonium sulphate with free phosphoric acid. The distinguishing point about these salts is their acid character, which produces the following series of properties.

1. *Great solubility in water.*—The salts composing these fertilizers dissolve readily in water, leaving only a faint residue of phosphates of iron and aluminum. They can therefore be applied like nitrate of soda as a top dressing as well as when the soil is poor in nutritive elements, a state of things which is only rendered evident by the weakly appearance of the plants.

2. *Ready admixture with lime and Thomas meal without loss of phosphoric acid and ammonia.*—It is well known to agriculturists that Thomas meal, on account of the caustic alkali which it contains, sets free ammonia when brought into contact with neutral salts of ammonium and with ammoniacal organic compounds, such as manure.

The presence of lime and a large proportion of ferric oxide transforms the soluble phosphoric acid of superphosphate into insoluble acid. There is no danger of losses of this kind when Thomas slag is used with the sulphophosphates of which we are speaking; but on the other hand, a part of the phosphoric acid of the slag is rendered soluble.

Experiments on the way in which these salts behave as compared with mixtures of slag and superphosphates have given the following results: On 100 parts of soluble phosphoric acid or nitrogen employed there were found:

A mixture composed as follows:	After standing for	With phos. of ammonia 10·24% N 25·56% phos. acid.		With phos. of pot. 21·57% 25·32% soluble phos. acid.	With superphos. 15·75% of soluble phos. acid.
		Nitrogen.	Phos. acid.		
100 grs. of slag.	670 days.	—	113·3	101·6	76·8
100 of fine meal (21% phos. acid)........	13 "	99·6	113·2	—	26·6
4% of lime with 23·56 grms. of phos. acid soluble in water.	32 "	99·6	111·7	100·0	—

It will be observed that phosphate mixed with slag retrogrades very rapidly, since at the end of thirteen days only 26·6 per cent. of the original weight of soluble phosphoric acid is present; with phosphate of potassium, on the other hand, there is no loss, but a slight gain (100·4 per cent.), while with ammonium phosphate a portion of the phosphoric acid of the slag is rendered soluble, and, far from any loss being experienced, the amount increases to 111·7 per cent. in thirty-two days.

In order to manure a piece of land simultaneously with slag or calcareous fertilizers, sulphate of ammonium and superphosphate, it would be necessary to work in each of these separately, which would greatly increase the labor expenses.

On the other hand, slag can be applied along with sulphophosphate of ammonium without inconvenience. This mixture is particularly valuable in certain cases, because a portion of its phosphoric acid dissolves rapidly, while the remainder only acts gradually as the plants develop.

3. *Rapid diffusion in the soil.*—In considering the way in which superphosphate and sulphophosphate respectively act in presence of Thomas slag, it appears probable that the soluble phosphoric acid of the sulphophosphates will be more rapidly disseminated in arable land than that of the superphosphate, submitted to the retrogressive action of compounds of lime, iron and alumina. Retrogression cannot, in fact, take place until the excess of acid has been saturated. This is why the phosphoric acid of the sulphophosphates should be more readily diffusible in heavy soil than the ordinary phosphoric acid of superphosphate.

I have also endeavored to treat this question experimentally, but the results obtained hitherto are not conclusive. I do not, however, consider it useless to discuss them here, and so draw the attention of others to the point.

The difficulty of the investigation evidently consists in reproducing the conditions of fertilization as they actually exist in practice, when small quantities of phosphoric acid are used for an enormous mass of earth. I commenced by preparing solutions of sal ammoniac and mineral superphosphate containing about 5 grammes of phosphoric acid per liter; 25 c. c. of this aqueous extract were reserved for analysis. Another portion of 25 c. c. was diluted to 500 c. c. and digested for two hours in a liter flask with 100 grammes of calcareous earth, the whole being frequently shaken. The liquid was then filtered and 400 c. c. of the filtrate, corresponding to 20 c. c. of the original solution, precipitated with ammonium molybdate.

In this way the following results were obtained:

	Sulphophosphates of Ammonium.	Mineral Superphosphate.
In 20 c. c. of solution employed...	0·0992 gr. phos. acid	0·0959 gm.
In 20 c. c. after treating with earth	0·0791	0·0725
Percentage of phosphoric acid rendered insoluble by treatment	20·3	24·4

Finally, the strongly marked acid character of the two salts explains how it is possible, even with a crude phosphate containing much oxide of iron and alumina, to make a phosphatic manure only containing small quantities of phosphate insoluble in water. I have thus succeeded, only upon the laboratory scale it is true, in preparing a sulphophosphate of potassium containing, in round numbers, 14 per cent. of soluble and 15·5 per cent. of total phosphoric acid from Nevassa phosphate, which is particularly rich in compounds of iron and aluminum. This salt was not oily, but had the consistency of a normal superphosphate. Special emphasis must be laid upon the fact that these salts are not hygroscopic, but as dry and pulverulent as superphosphates in general. At the commencement difficulties were encountered in this respect, but they were long ago overcome.

I must add that in the sulphophosphates of potassium and ammonium the phosphoric acid, the nitrogen and the potash have a high fertilizing value, while their price is not much higher than that of simple mixtures of superphosphate, ammonium sulphate and potassium sulphate.

It is true that in the sulphophosphates half the base is combined with phosphoric acid, but on the other hand, their characteristic properties give them a much greater value than mere mixtures of these salts. Thanks to the absence of injurious material (compounds containing chlorine), they are suitable for the cultivation of tobacco, the vine, etc. Their great solubility in water fits them for use as a top dressing, their acid properties render them valuable for mixing with other fertilizers, and finally their great concentration means a great saving in carriage, when they are sent to places at a distance from the works.—*L'Engrais.*

BOTTLED GASES.

"LEAVE orders for oxygen under the door" is the odd legend that greets the eye in the second floor hall of an upper Broadway building. The door in question leads to the living apartments, to use a complimentary plural, of the dealer in oxygen. His office is the front hall room on the same floor, sufficiently cramped quarters for one whose stock in trade is of so expensive a nature. He is one of a great many persons whose business it is to purvey wind, sweetened and otherwise, to the inhabitants of this town.

The sale of invisible and almost intangible and imponderable merchandise is one of the most curious of the many strange business developments of this great community. You may buy bottled gases as you buy bottled beer, and have them delivered at your house as newspapers, or soda, or fresh vegetables are delivered. Oxygen, hydrogen, nitrogen and carbonic acid are sold daily, as boots and shoes are sold. They are handled with indifference, just as other freight is handled, sent by express, carried on the backs of nonchalant messenger boys, and, in fact, treated as if they were not tremendously expansive agencies packed away under a pressure of 1,800 pounds to the square inch. One factory sells 30,000 feet of oxygen per month, and keeps on hand nearly that quantity in storage tanks. That volume of the gas weighs more than a ton and a quarter. Several other concerns sell nearly as much more, and a large quantity of hydrogen is sold to go with it for use in producing the lime light at theaters, lectures and clinics.

Besides this, oxygen and hydrogen are sold in mixtures of various proportions, and a great volume of nitrous oxide or laughing gas is sold to dentists, surgeons and hospitals. The makers of aerated waters buy carbonic acid in large quantities, and it is used elsewhere in the arts. Its use for aging wines, long practiced in France, is scarcely known here. Carbonic acid is usually sold in liquid form. Nitrogen is sold in small quantities for experimental purposes. It can be produced in almost unlimited quantities for experimental purposes. It can be produced in almost unlimited quantities at low rates, since it is given off as a waste product in one process of making oxygen.

Not only are gases sold in large quantities to local consumers, but they are sent by express all over the country. Laughing gas, in particular, has an enormous sale in various parts of the United States, and is also shipped to the most remote parts of civilized South America. The express companies handle this peculiar freight without special charge, and the makers say that accidents never occur.

The local trade in oxygen has a great many curious kinks. The various kinds of medicinal air advertised are, or pretend to be, mixtures of oxygen with atmospheric air. One dealer in the wind cure, however, assured the agent of an oxygen factory that oxygen was by no means a necessary part of his cure. A little perfume furnished by himself at low cost and a good deal of imagination furnished free by the patient proved vastly cheaper and quite as effective. The use of oxygen upon physicians' prescription is considerable, and many patients order it delivered two or three times a week, and keep up the practice long after the prescription is given. It is taken finally like any other tonic or stimulant, and not infrequently recommended to others. One concern sells over 250 pounds of oxygen per month for such purposes, and supplies several thousand customers.

If you see a messenger boy carrying on his back an iron cylinder about 30 inches long and five inches in diameter, you may be pretty sure that he is taking some person his supply of gas. If the cylinder is painted red, it contains oxygen; if black, hydrogen; if particolored, laughing gas. The manufacturers have come to an agreement as to colors because such agreement seemed necessary to safety. When oxygen and hydrogen are carelessly mixed, an explosion follows. To make it the more difficult to confuse the cylinders, the screw threads on the red cylinders and on the black cylinders are run in opposite directions, so that it shall be impossible to couple a cylinder to the wrong reservoir. By way of further precaution the cylinders are tested to a pressure of 4,000 to 5,000 pounds to the square inch.

Cylinders hold from 75 to 450 gallons of gas, and gases are sold by the foot for use in the arts, by the gallon for medical use. The fight that has been made over the return of beer bottles and soda siphons has likewise been made on the return of gas cylinders. The manufacturers have finally settled down to a system under which the cylinder is in theory sold outright, though in practice the purchase price, less a charge for rent, is refunded on return of the cylinder. By a system of checks and numbers the dealers can locate each missing cylinder.

The United States government is likely soon to become an important consumer of oxygen, as it is shortly to be applied to use in the torpedo service. An expert in gases, now resident in this city, gave Goubet, the French designer of torpedo boats, an important hint on this subject. Goubet had a tiny submarine craft, and he was accustomed to load it before starting on a submarine cruise with great cylinders containing compressed air. As the air loose in the little craft became

contaminated, it was freshened by pure air let out by the cylinders.

The expert suggested the use of pure oxygen instead of air, and at Goubet's suggestion made a careful investigation of the subject. He came to the conclusion that he could store in one-thirtieth of the space occupied by Goubet's compressed air cylinder enough oxygen to do the work of the air thus carried. He also suggested a simple device for detecting the presence of too much oxygen or too much carbonic acid in the atmosphere of the boat. His device was to light a tiny night lamp, such as is used in the sick room. He knew that the flame would almost die in the presence of a dangerous percentage of carbonic acid, and that it would dilute when the proportion of oxygen was too great.

On the day set for the experiment the little boat was stocked with oxygen in cylinders under a pressure of 1,800 pounds to the square inch. The cylinders were provided with valves that would permit of only a very slow escape of the gas. The night lamp worked to perfection, and Goubet and his companion remained four hours under water with no greater supply of air than was free in the tiny craft when they descended. The oxygen kept the atmosphere in such condition that they were able to breathe in comfort, and they spent the time in conversation, at luncheon and at cards. Goubet has continued the experiments on his own hook, and has kept his boat submerged for six hours. The experiment has not yet been tried in torpedo service on this side of the water.—*N. Y. Sun.*

DETERMINATION OF FERRIC OXIDE AND ALUMINA IN PHOSPHATES.

By R. JONES.

TEN grms. of the sample are dissolved in nitric acid and made up to 500 c. c., 50 c. c. of this solution (= 1 grm. of the original substance) are evaporated down to one-half in a beaker, mixed while still hot with 10 c. c. dilute sulphuric acid (1:5), stirred up, 150 c. c. of alcohol are added, and after again stirring are allowed to stand for at least three hours. The calcium sulphate is collected upon a filter and washed with alcohol, filtering into an Erlenmeyer flask holding from 400 to 500 c. c. The washing is complete when the last ten drops, after dilution with an equal volume of water, are no longer reddened by a drop of methyl orange. A small Sprengel pump is very serviceable in washing.

If it is intended to weigh the calcium sulphate, it is laid while still moist in a planitum capsule, the filter is laid upon it, the alcohol is burnt away, and the mass ignited with a moderate flame until its weight is constant. The ignited calcium sulphate is not so hygroscopic as to interfere with working in an open capsule.

The alcohol is distilled off from the contents of the flask. It is contaminated with hydrochloric acid or nitric acid and their products of decomposition, and cannot be used again until it has been once more distilled over soda.

The residue from the distillation is washed into a beaker, slightly supersaturated with ammonia, and heated until all the ammonia has been expelled. This precaution is very necessary, as otherwise the precipitate of iron phosphate will be mixed with magnesia.

The residue is collected on a filter; the residues adhering to the glass are swept upon the filter by means of a glass rod tipped with caoutchouc and a jet of cold water. It is washed four times with boiling water poured out from the reversed washing bottle, in order not to stir up the precipitate. In this manner we always obtain clear filtrates. For still greater security a little ammonium nitrate may be added to the washing water, which of course must not be acid. The precipitate is ignited and weighed.

The precipitate is assumed to consist of ferric and aluminum phosphate, exactly one-half of which is the joint weight of ferric oxide and alumina.

If the operator prefers to determine the ferric oxide and alumina as such, the mixed precipitate when ready for weighing may be dissolved in nitric acid, the phosphoric acid precipitated with the molybdic solution, filtered and washed; the ferric hydroxide and alumina may be precipitated in the liquid by ammonia and weighed.—*Zeitsch. Anal. Chemie*, xxx., p. 742; *Chem. News.*

PHOTO-CHEMICAL NOTICES.

By P. ASKENASY and VICTOR MEYER.

IN a memoir on the slow combustion of gaseous mixtures, the authors mentioned that V. Meyer and Krause had exposed detonating gas for some months to the light of the sun in closed vessels without any formation of water being observed. No decisive value was ascribed to these experiments, as they were performed during the winter months. We have latterly repeated them, exposing bulbs of detonating gas to solar radiation uninterruptedly from May to October. But here also no change of volume was perceptible on opening the bulbs. It must be added that these results were obtained with the *dry* gaseous mixture. It remained, therefore, to be examined whether the behavior of moist detonating gas would be similar.

If, therefore, a formation of water could not be effected by irradiation alone, it might possibly be produced if detonating gas were exposed to the sun's rays at atmospheric pressure and at a temperature immediately below its point of ignition. For this purpose the intense light of a July sun was concentrated by a large concave mirror, and thrown downward by means of a metallic plane mirror upon *moist* detonating gas kept at 606° in boiling stannous chloride. Ignition, however, was not observed.

The authors further communicate some experiments undertaken to submit to a renewed test the accuracy of Draper's statements on the photo-chemical induction of chlorine. Draper maintained that a chlorine detonating gas composed of chlorine and hydrogen previously irradiated possesses the property of combining to form hydrochloric acid, even in the dark. Bunsen and Roscoe have rejected this observation as incorrect, showing that chlorine which had been passed outside the laboratory through a glass worm exposed to the rays of the sun, and was then mixed with hydrogen which had been similarly isolated, remained inactive on mixture with the latter in darkness. Against this method of experimentation the objection might be made that the chlorine had been exposed to the chemically active rays for too short a time; possibly a prolonged stage of induction might be required. The authors therefore repeated the experiments in a modified form, exposing chlorine in a long vessel containing 100·5 c. c., and capable of being closed at each end by means of glass cocks for three to four hours to the light of a July sun, the intensity of which was increased by means of a concave mirror. It was then shaded, the apparatus was placed in a vertical position, and 50 c. c. of hydrogen which had been similarly illuminated were introduced from above from a gas burette, while the displaced chlorine could escape at the lower aperture of the apparatus. The analysis of the gaseous mixture which was expelled after some time from the darkened space by means of pure carbonic acid, and collected over soda lye, showed that no hydrochloric acid had been formed, and the exact quantity of hydrogen taken had been recovered. Hence it is demonstrated that chlorine, even if irradiated intensely and for a long time, and hydrogen, similarly treated, do not combine with each other if at once introduced into darkness.—*Justus Liebig's Annalen der Chemie*, cclxix., p. 72.

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